Tsunami Monitoring and Warning Mechanism

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What is a Tsunami ?

- A system of ocean gravity waves formed as a result of large-scale displacement of sea surface. Travel long distances without losing energy

- "Tsunami" in Japanese means "harbor wave"

Indian Ocean Tsunami of December 26, 2004

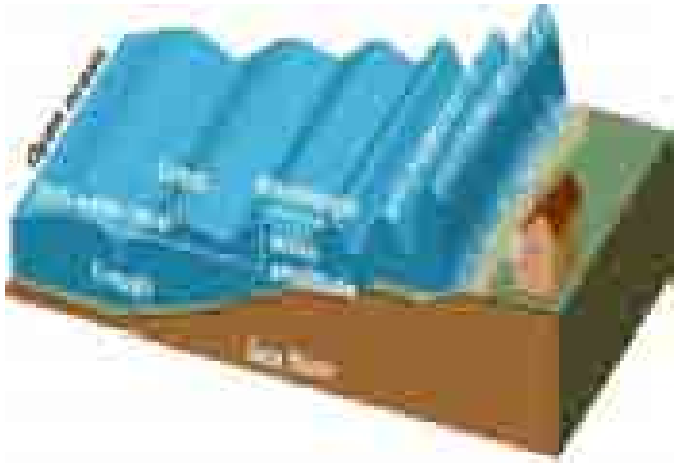
- The worst tsunami in recorded history on December 26, 2004
- Magnitude 9.3 (second strongest earthquake ever recorded on a seismograph)
- Lasted 10 minutes (longest lasting earthquake in history)
- 229,866 confirmed dead, which includes 42,883 missing and never accounted for
- More than $7 billion dollars damage

Reasons for huge loss…..

- Many nations in the Indian Ocean did not even recognize the word “tsunami”
- None had tsunami preparedness programs in place
- Absence of a Tsunami Early Warning System (TEWS) in India
- Ignorance of the natural signs of a tsunami led to inappropriate actions

Tsunami Characteristics

- Length and Time Period
  - Long wave length (of several 100 km)
  - Periods of a few minutes to about an hour
- Speed proportional to square root of water depth
  - 500 to 1000 km per hour in Deep Ocean
  - About 30 km per hour near shore
- Height of Tsunami Wave
  - Less than a meter in the Deep Ocean
  - Grows to Tens of meters near shore



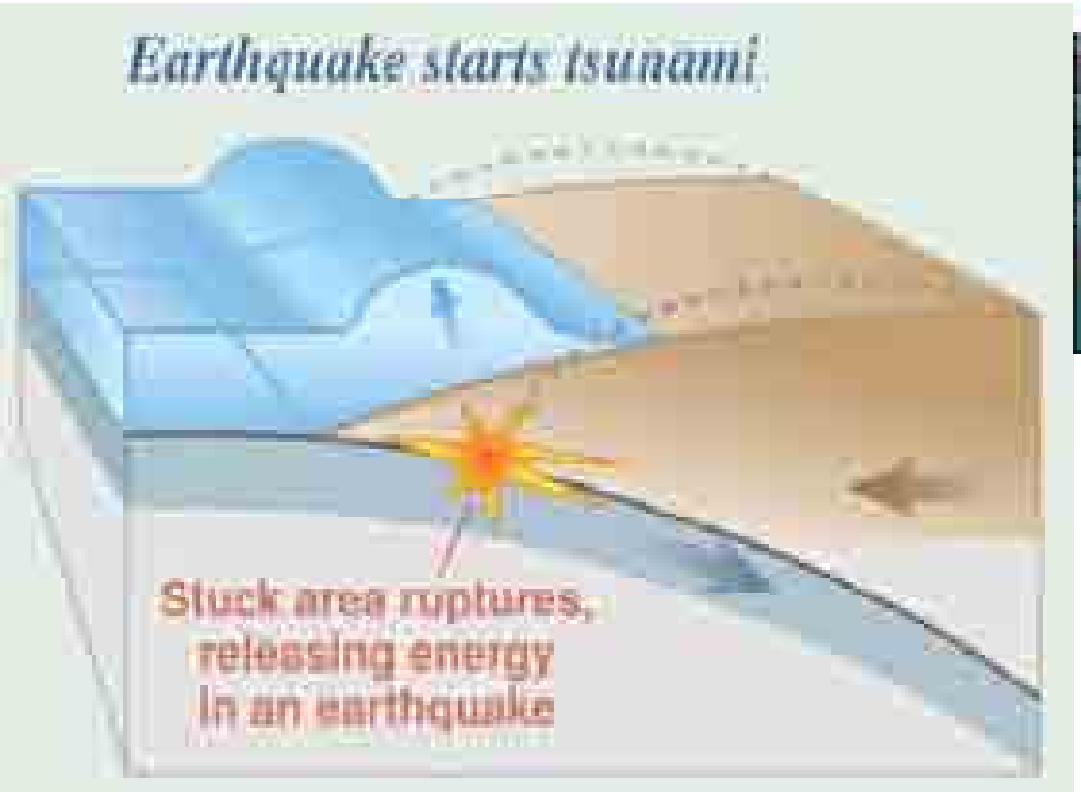
IN DEEP OCEAN tsunami has long wavelength, travels fast, small amplitude -

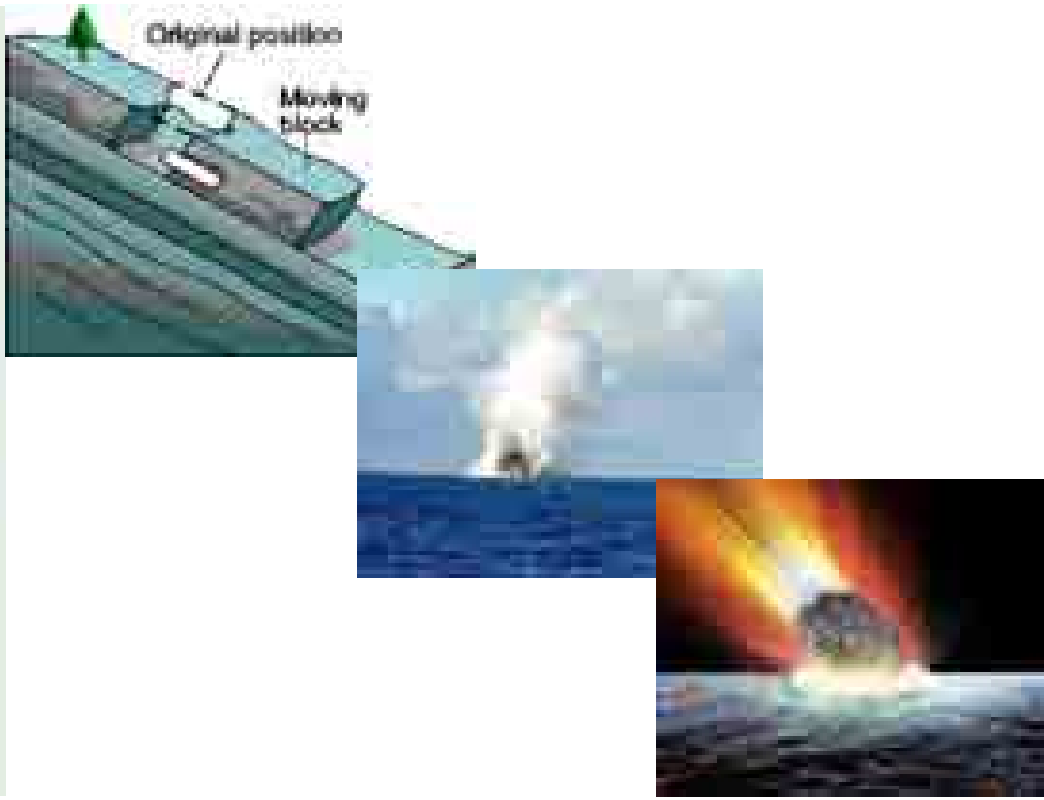
AS IT APPROACHES SHORE, it slows. Since energy is conserved, amplitude builds up -

Causes of Tsunamis

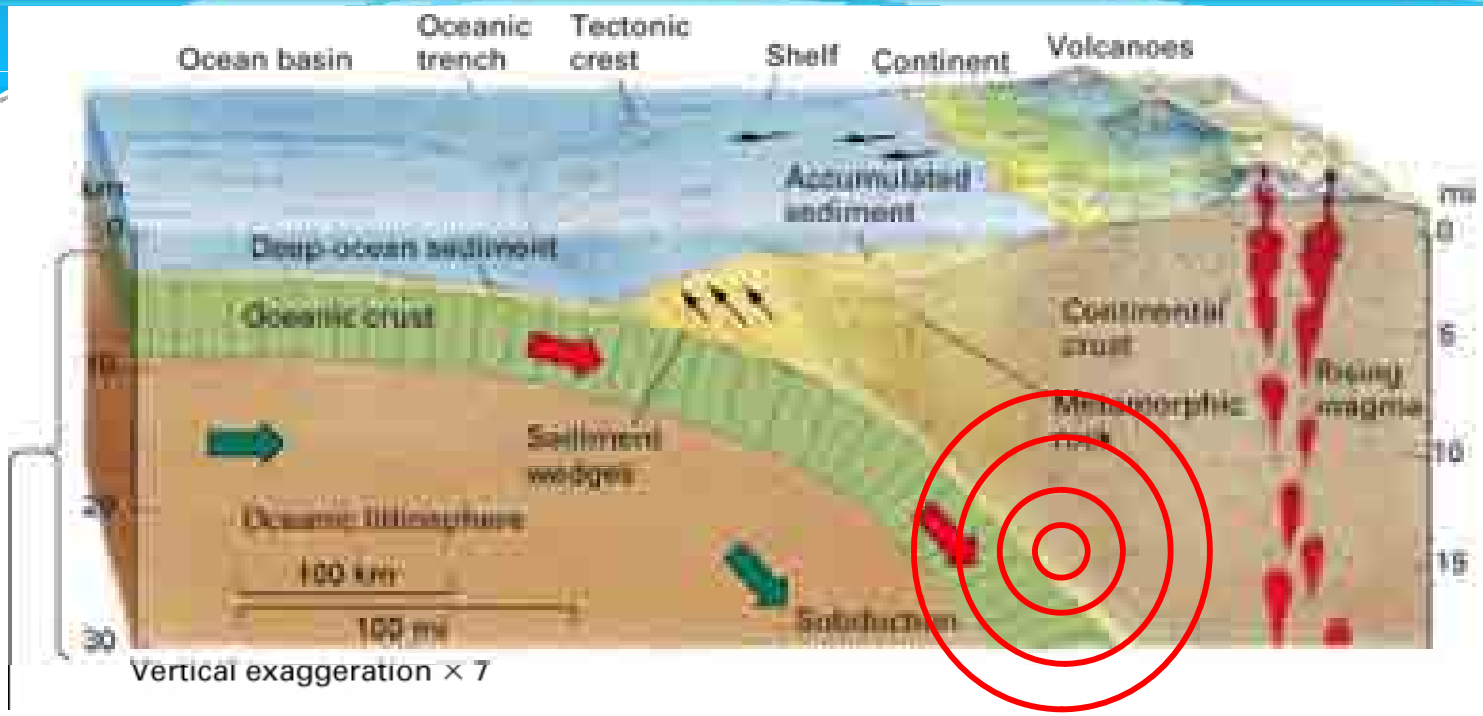
Any impulse that causes <u>large scale displacement</u> of the sea surface.

- **Earthquakes**
- **Landslide**
- **Volcanic eruptions**
- **Meteoroids Impact**





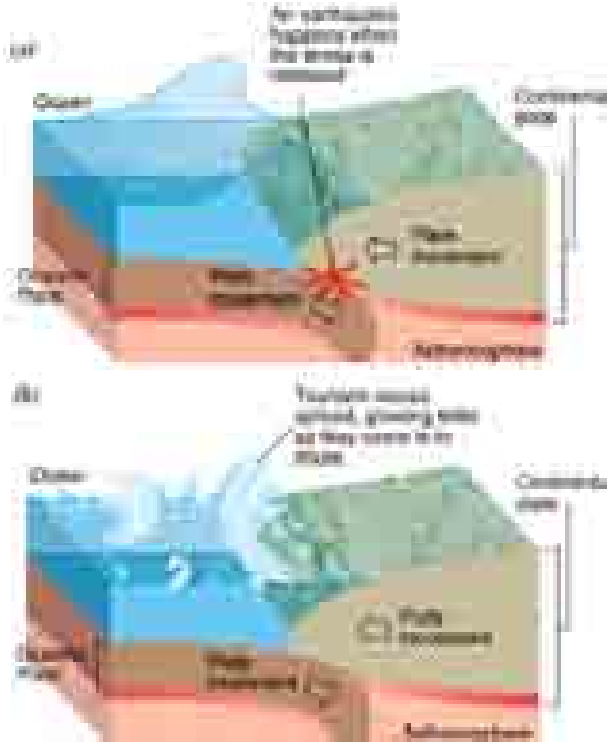
Subduction Zone Earthquake



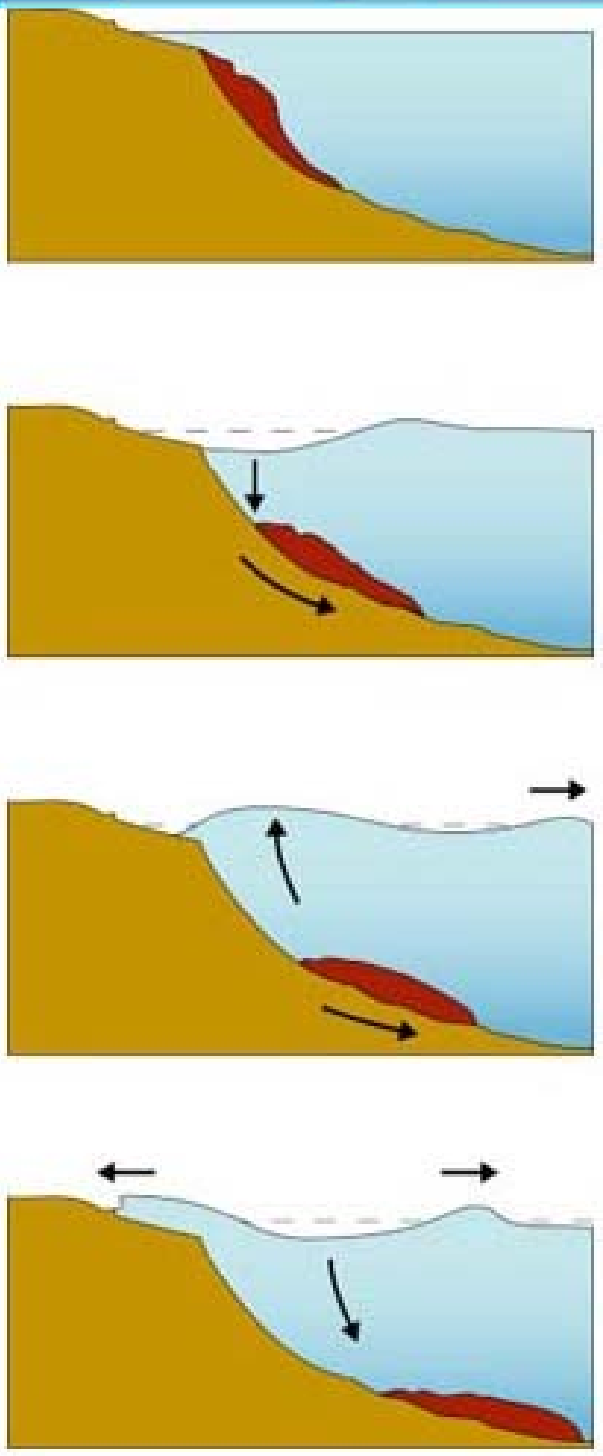
(e.g. Sumatra, 2004: >200,000 people killed; Papa New Guinea, 1998: ~3,000 people killed)

- Oceanic crust collides with continental crust and is forced downward
- Compression forces build until rock fractures and an earthquake occurs
- **When an earthquake occurs, the energy travels outward in all directions.**

  For the epicentre, the energy causes a sea wave to move away at great speed.



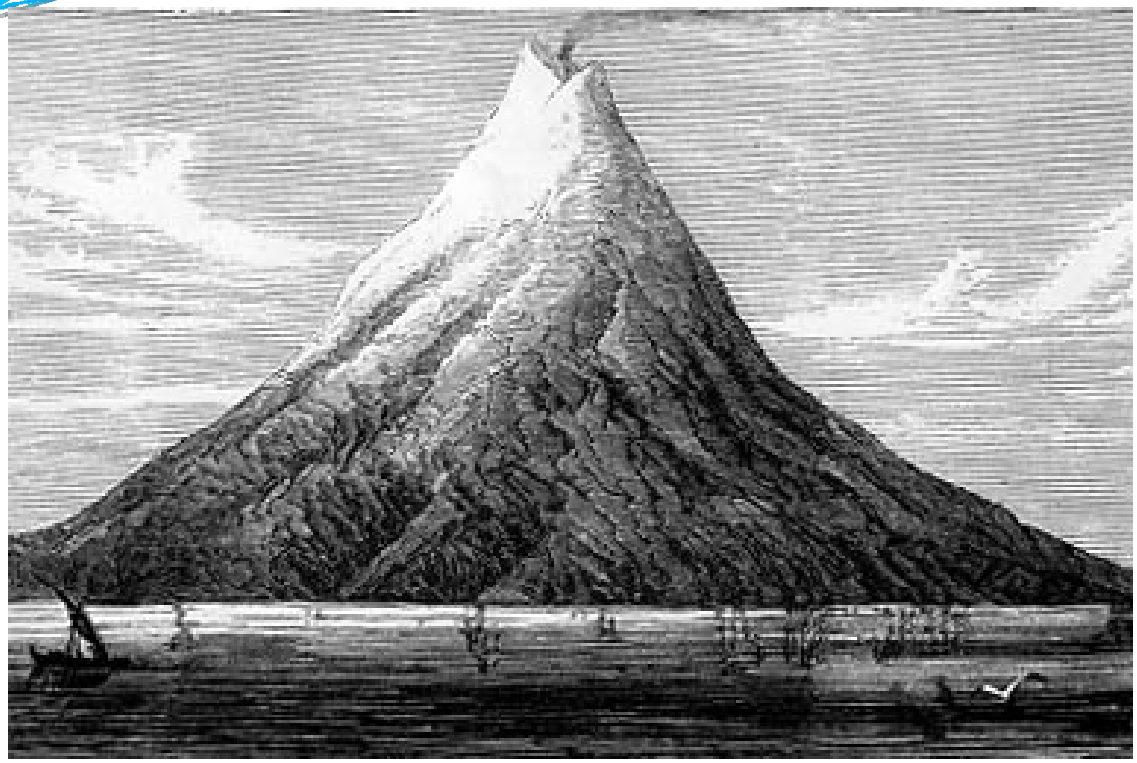
Undersea Landslide or Slump

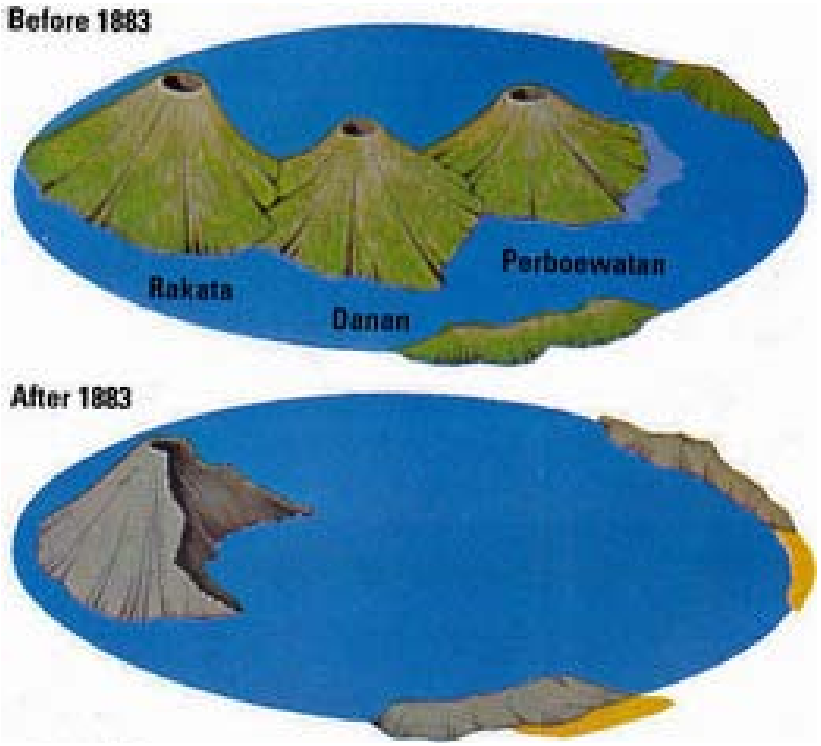


- Body of sediment slumps downward along a continental shelf
- Can be triggered by an earthquake
- Water drops at head of slump, rises at toe to create a wave
- Wave moves outward as a tsunami

Mass Movement (e.g. Alaska, 1958: waves up to 518 m high formed in Lituya Bay).

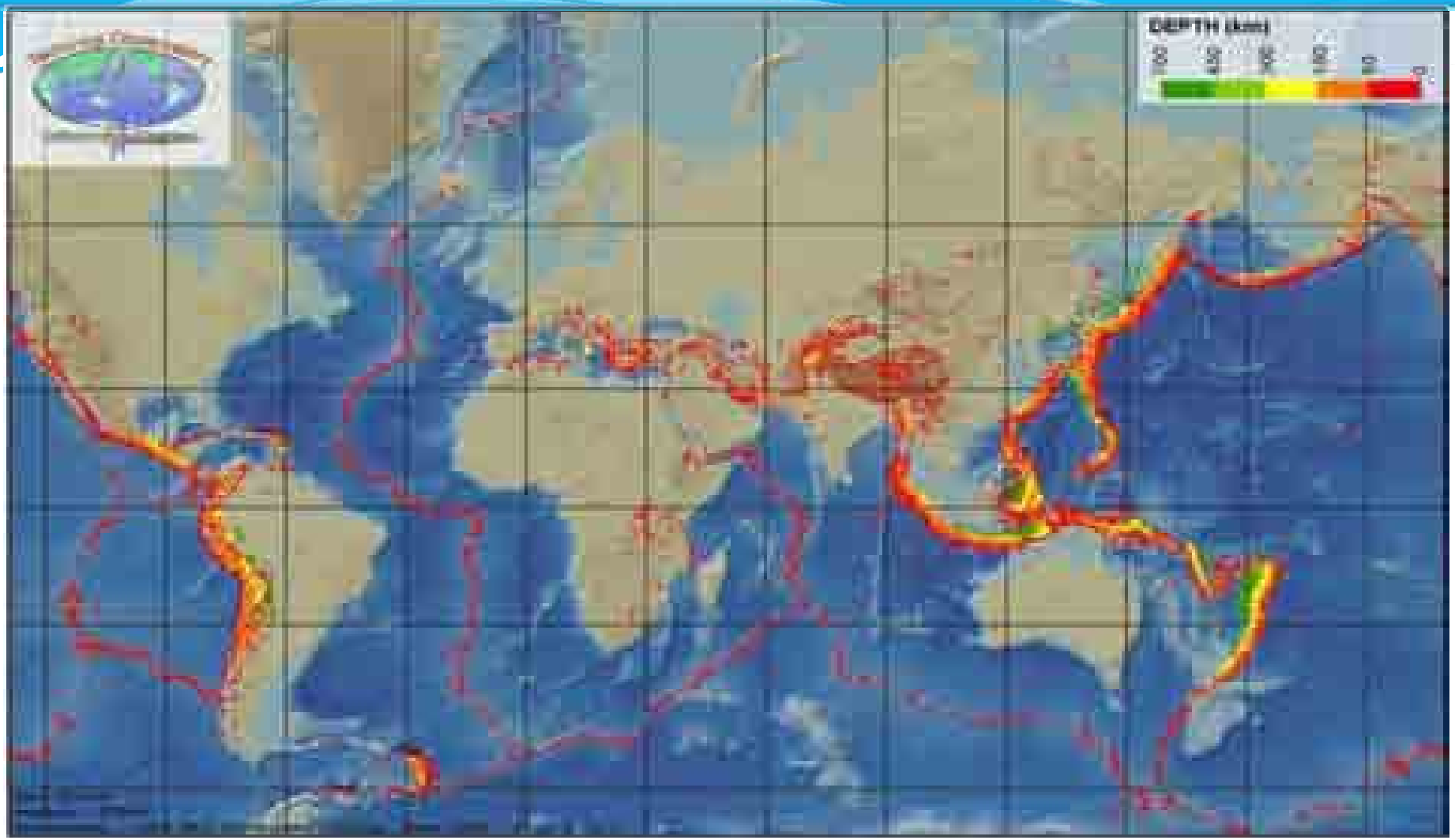
Volcanic Explosion





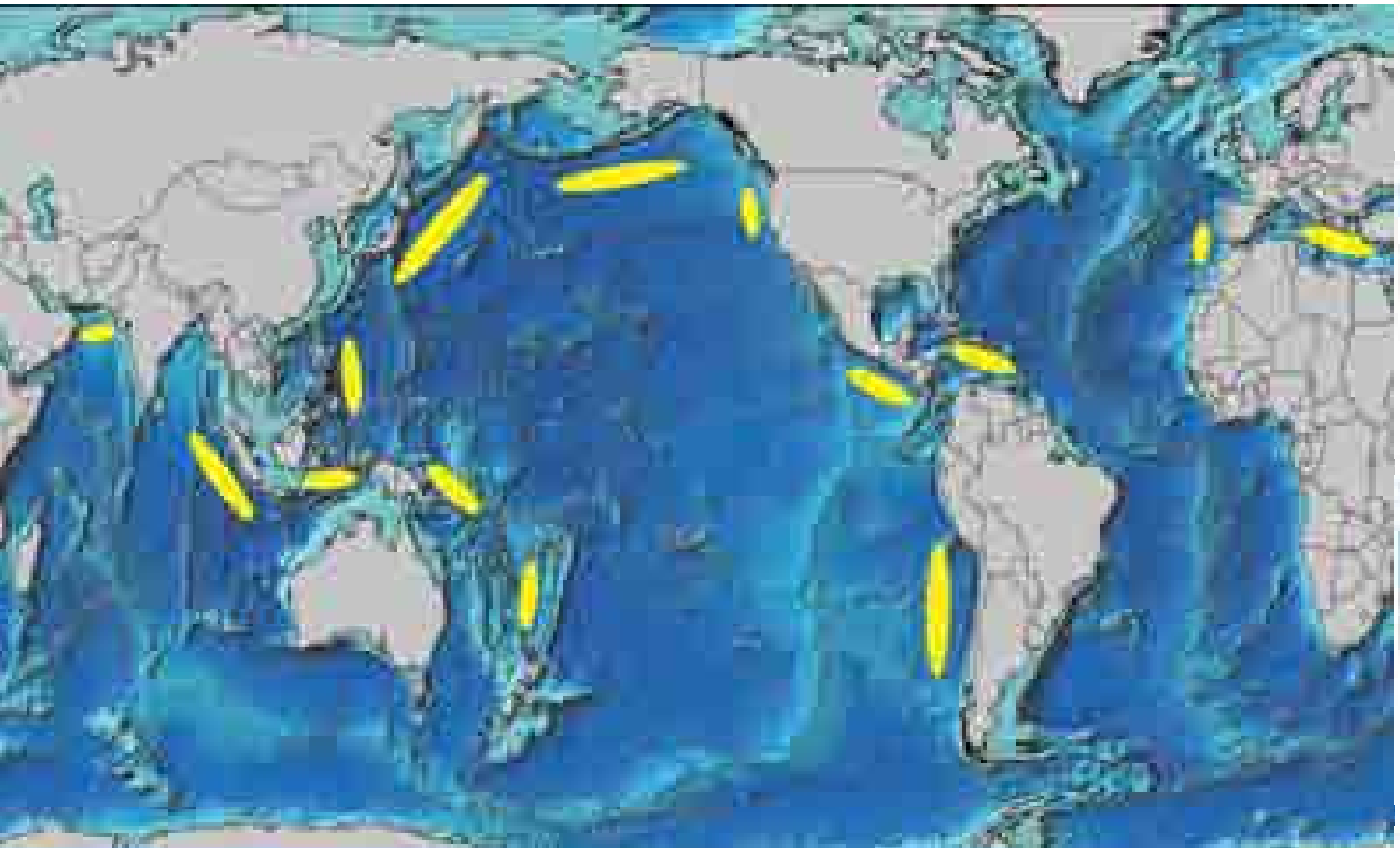
- The explosive eruption of Krakatau in August 1883 created a tsunami that claimed more than 36,000 lives

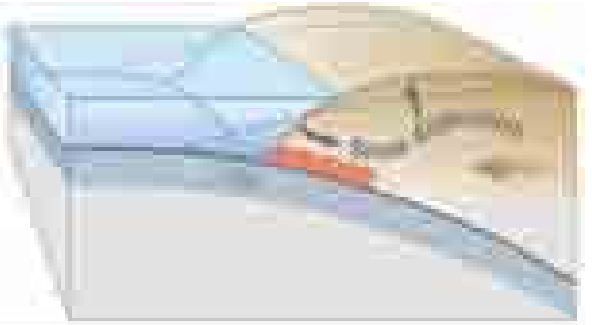
Global Seismicity



- ~80% of all earthquakes occur in the circum-Pacific belt
- ~15% occur in the Mediterranean-Asiatic belt
- remaining 5% occur in the interiors of plates and on spreading ridge centers
- more than 150,000 quakes strong enough to be felt are recorded each year

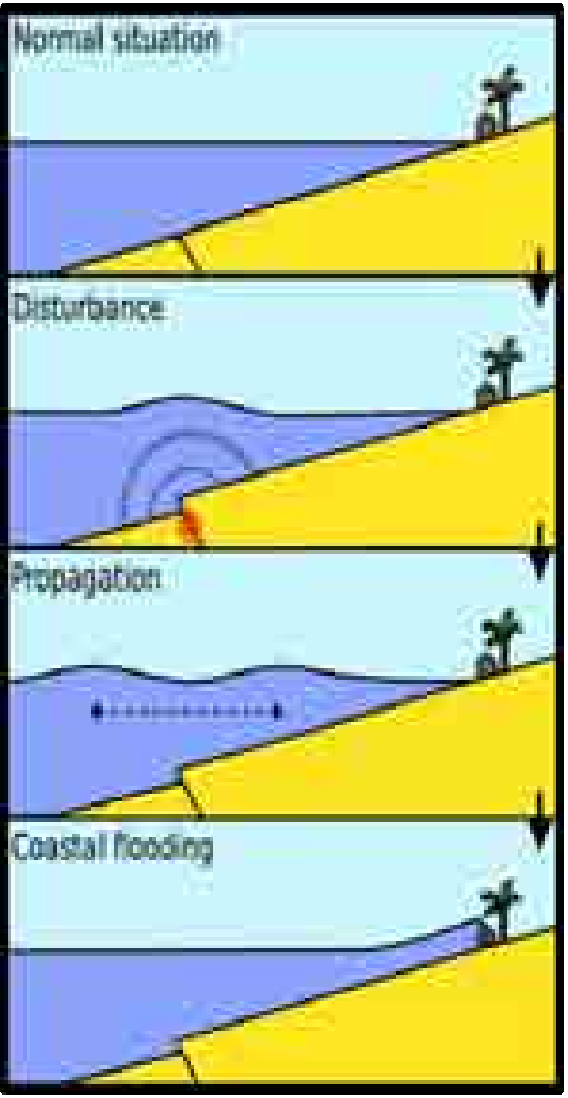
Tsunami Source Regions





Tsunami Characteristics

What happens during Tsunami?
Tsunami is a series of waves

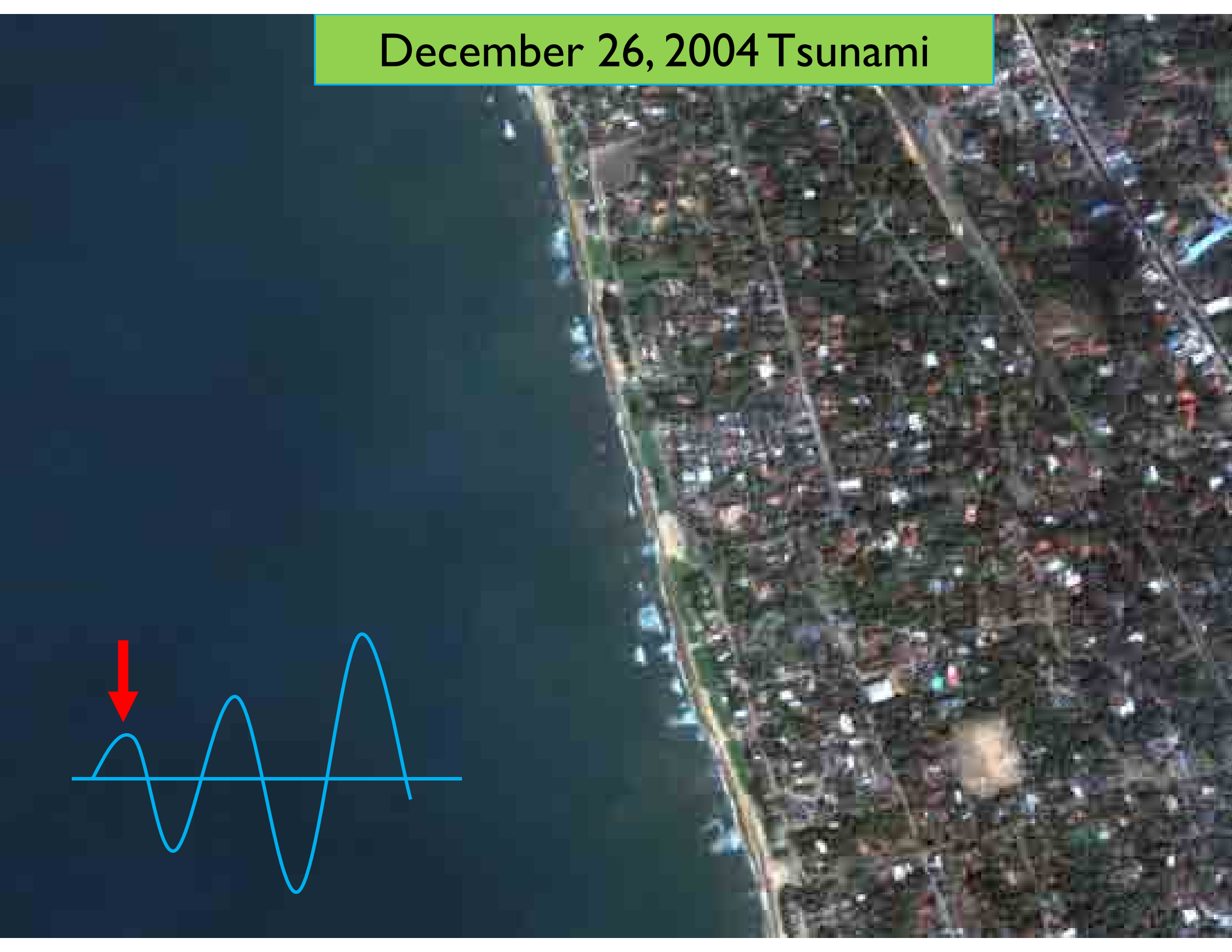


Generation

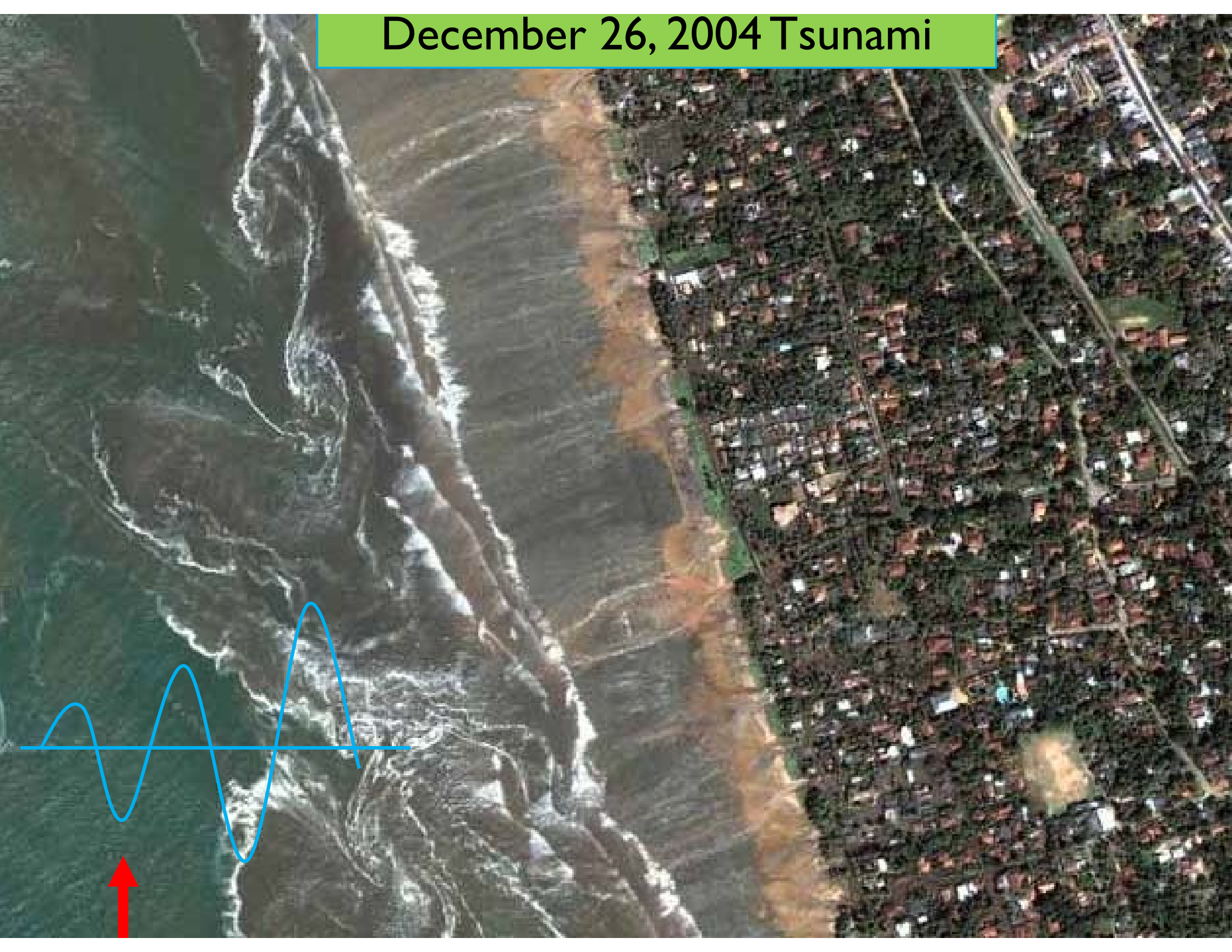
Propagation

Inundation

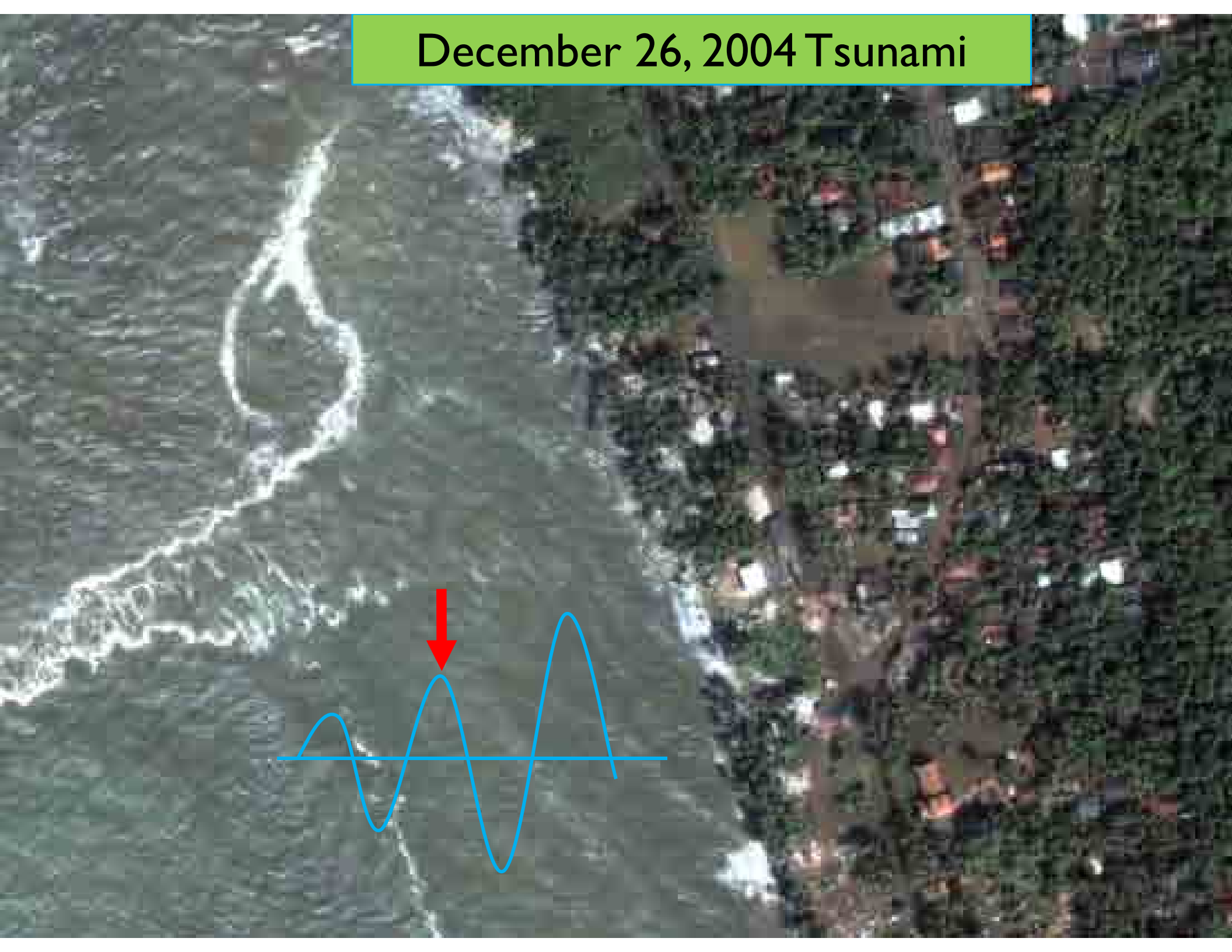
December 26, 2004 Tsunami



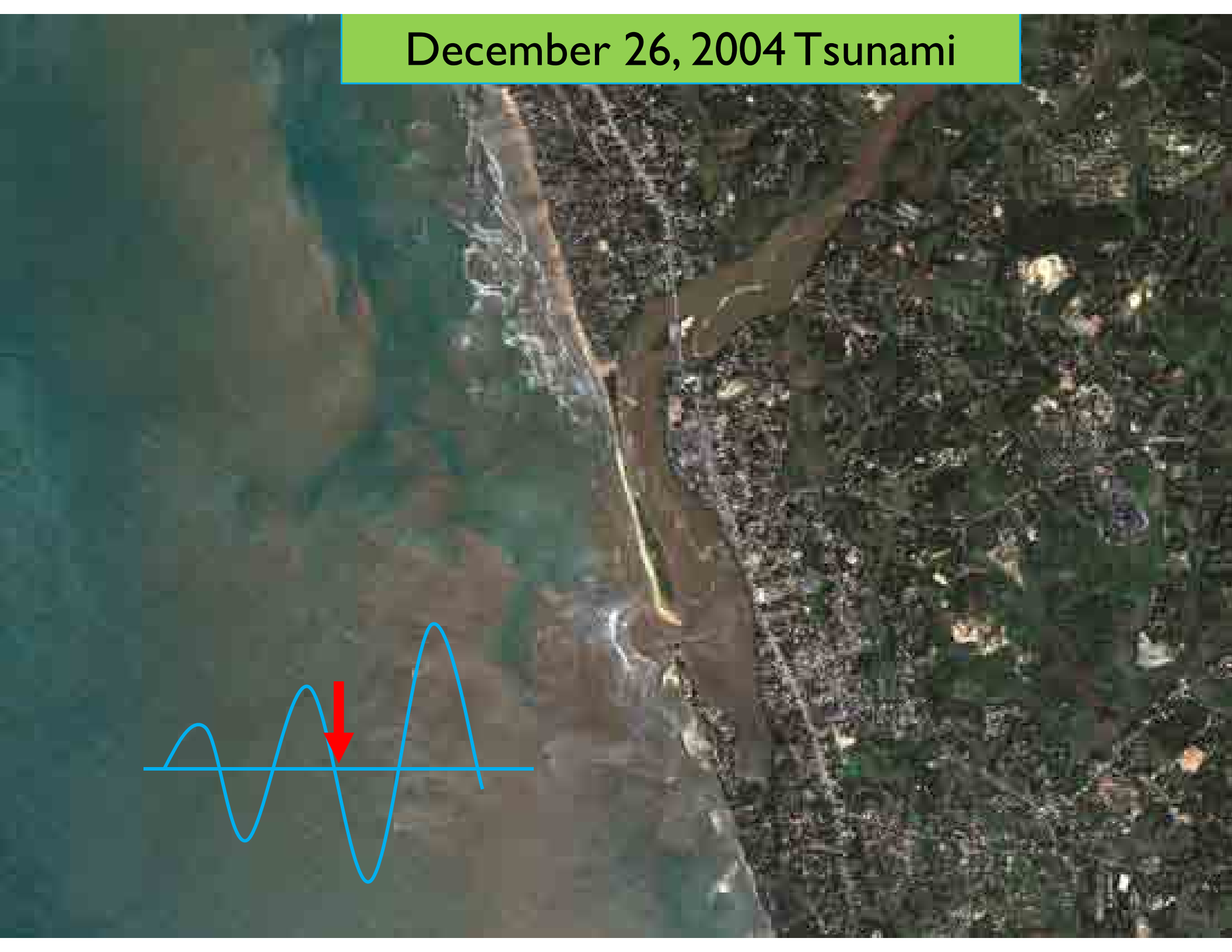
December 26, 2004 Tsunami



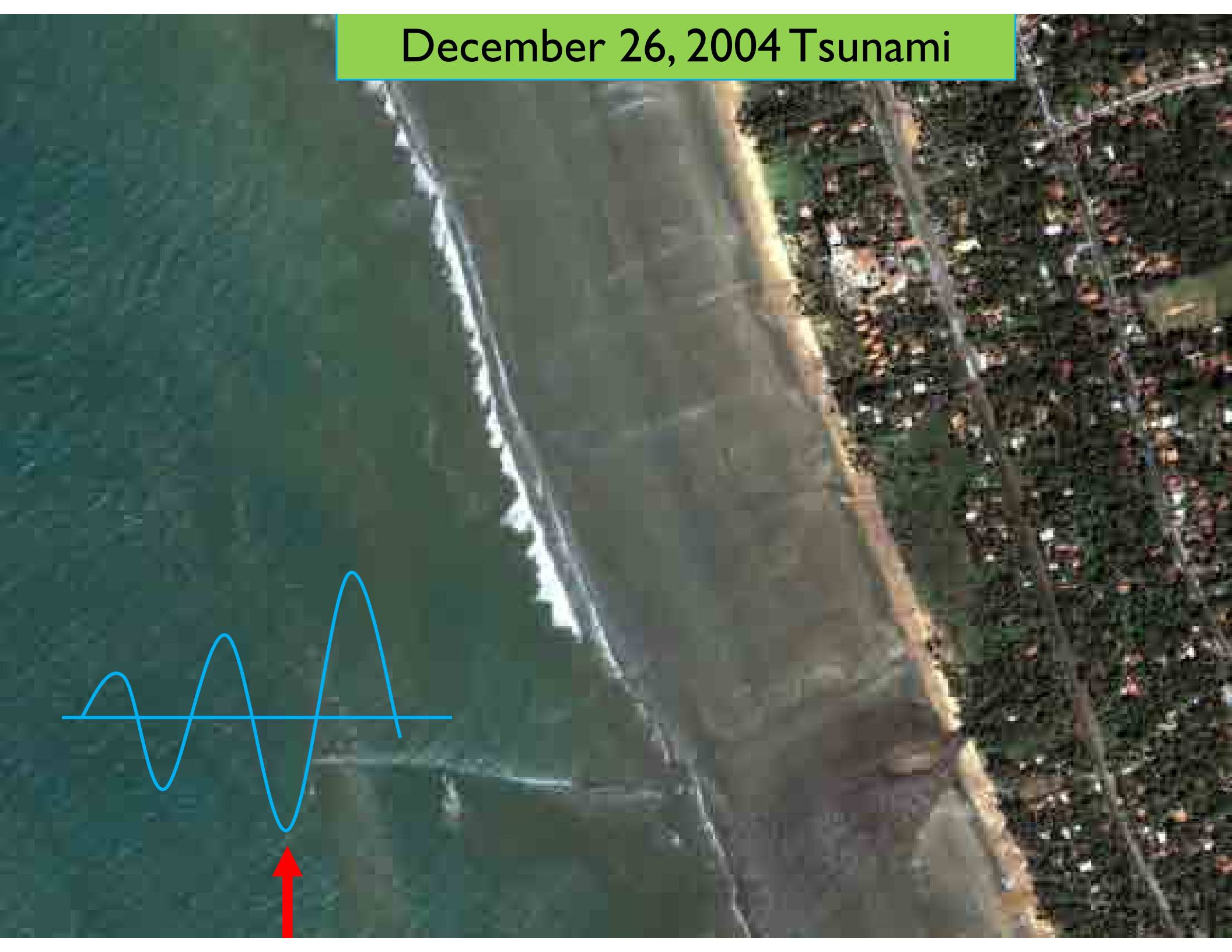
December 26, 2004 Tsunami



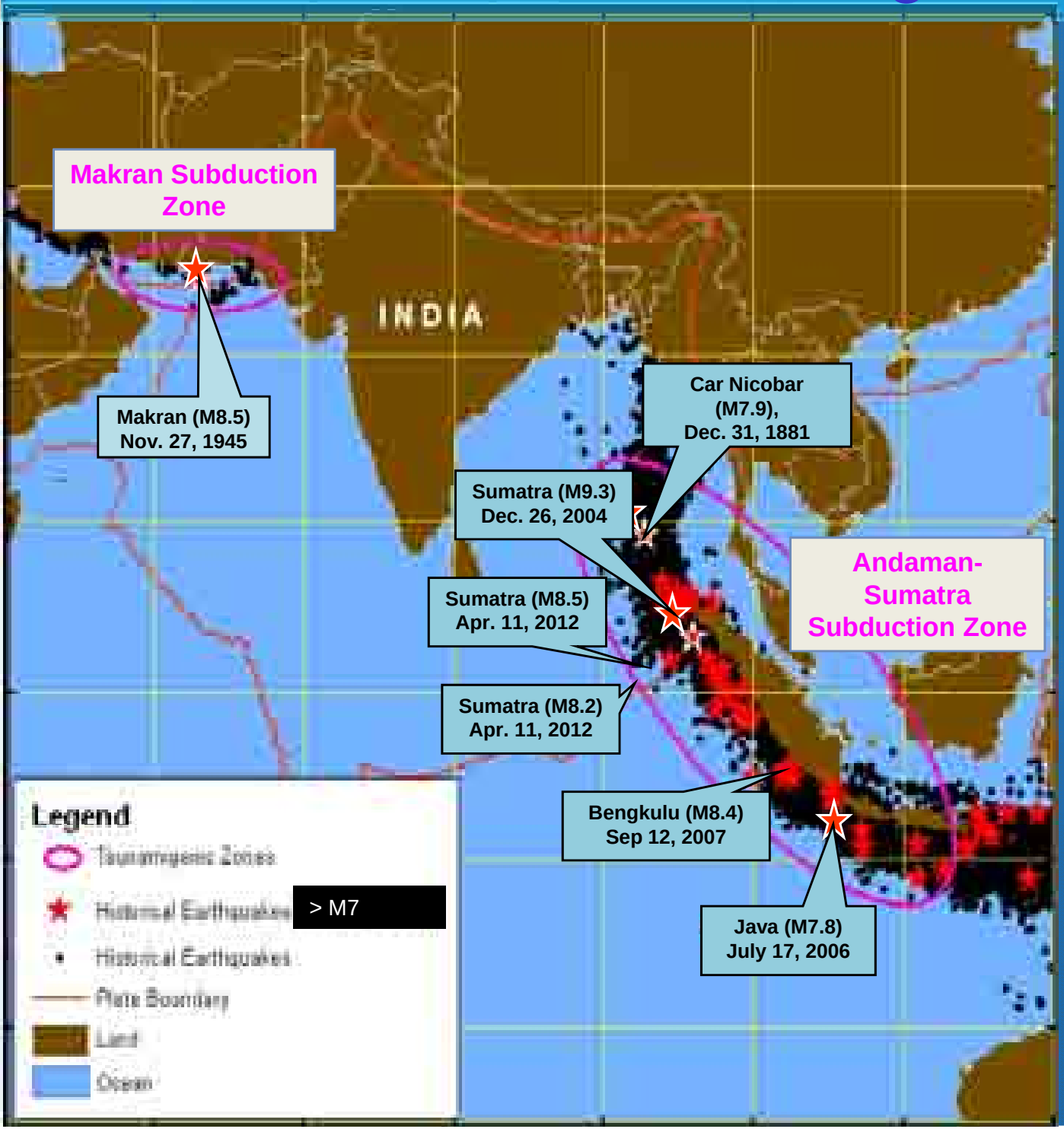
December 26, 2004 Tsunami



December 26, 2004 Tsunami



Potential Tsunamigenic Zones



Tsunamis are primarily caused due to large undersea Earthquakes.

For a tsunami to hit Indian coast, it is necessary that a tsunamigenic earthquake occurs and its magnitude should be larger than M 7. Possible locations of such events are enclosed in ellipse

Earthquakes with Slow Rupture Velocities are most efficient Tsunami Generators

75% of earthquake energy is released in the circum-Pacific belt – 900 Tsunamis in 20th Century

20% in the Alpine-Himalayan belt – 6 Tsunamis in 20th Century

Historical Tsunami in India

12 Apr, 1762 (BoB EQ) – 1.8 M
31 Dec, 1881 (Car Nicobar EQ)
27 Aug, 1883 (Krakatoa) – 2 M
26 Jun, 1941 (Andaman EQ)
27 Nov, 1945 (Makran EQ) – 12 M
26 Dec, 2004 (Sumatra EQ)

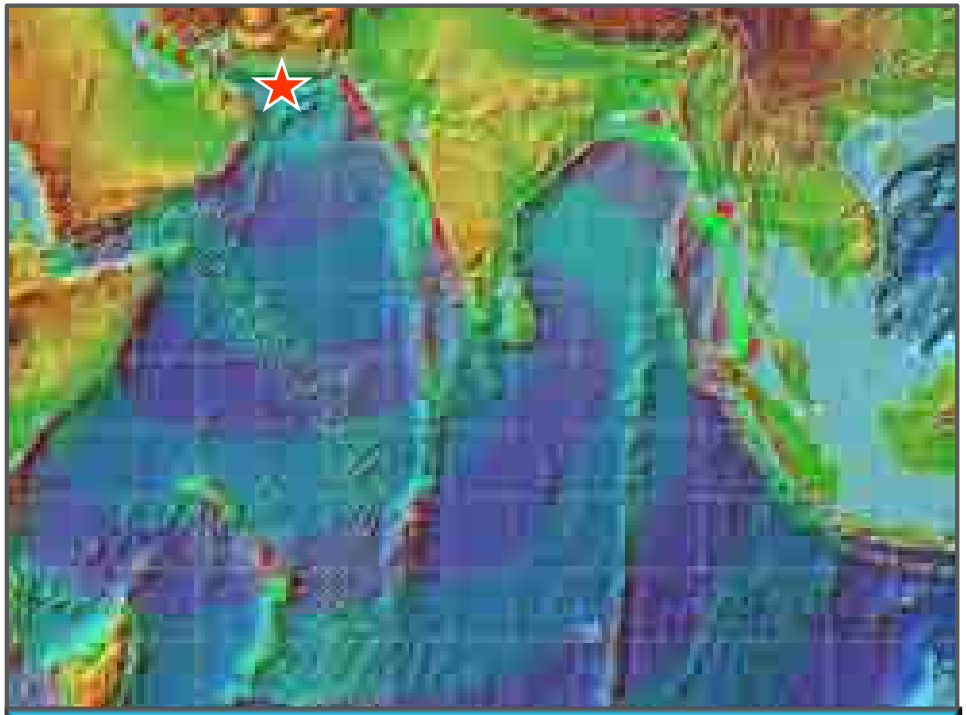
Landslides, Volcanoes & Meteor Impacts can also generate Tsunamis

Tsunami Risk Assessment

Tsunami Travel Times & Response time

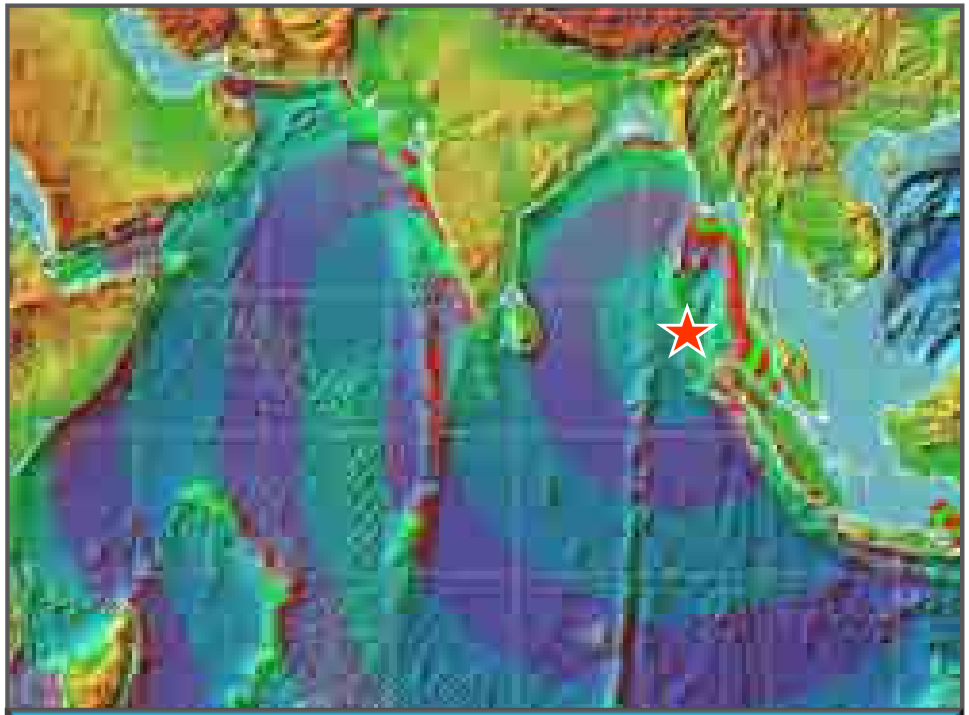
- Depending upon the Earthquake location (Makran/Andaman-Sumatra Subduction Zone) the response time for evacuation of coastal population could range between 10 min to few hours.
- As Andaman & Nicobar Islands situated right on subduction zone the available response time is very short

Makran Subduction Zone



- **If Earthquake occurs at Makran Subduction zone, Travel Time to nearest Indian Coast (Gujarat) are 2 to 3 hrs**

Andaman-Sumatra Subduction Zone



- **If Earthquake happens at Nicobar Islands , travel times to nearest coast (A&N Islands) are 20 to 30 min**
- **For Indian main land travel times are 2 to 3 hrs**

Tsunami Early Warning System

Detection → Warnings → Dissemination

Participating Institutions
IMD, NIOT, ICMAM, SOI, NRSC, INCOIS
MHA, NDMA, Coastal States


Seismic Network


BPR Network


Tide gauge Network

Observation Networks


VSAT


INSAT


GPRS

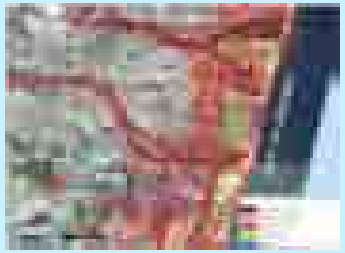

INMARSAT

Communications


Bathymetry


Tsunami Modelling


Topography


Costal Vulnerability

Modelling

COMMS Tests
Tsunami Drills
Trainings
Publicity Material

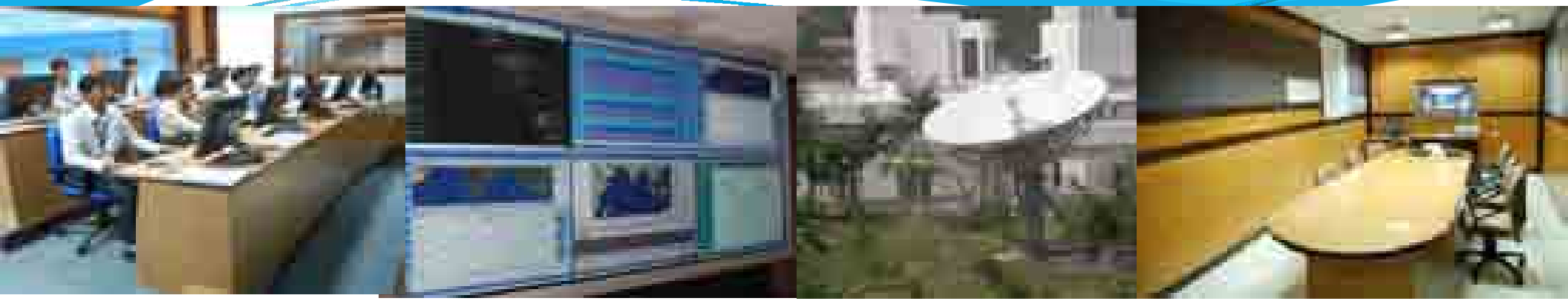

Capacity Building


R & D

Paleo-tsunami Modelling
GNSS Data Use

Last mile connectivity

Tsunami Early Warning Centre



24 x 7 operations

Heterogeneous Real-Time Data from a variety of Sensors

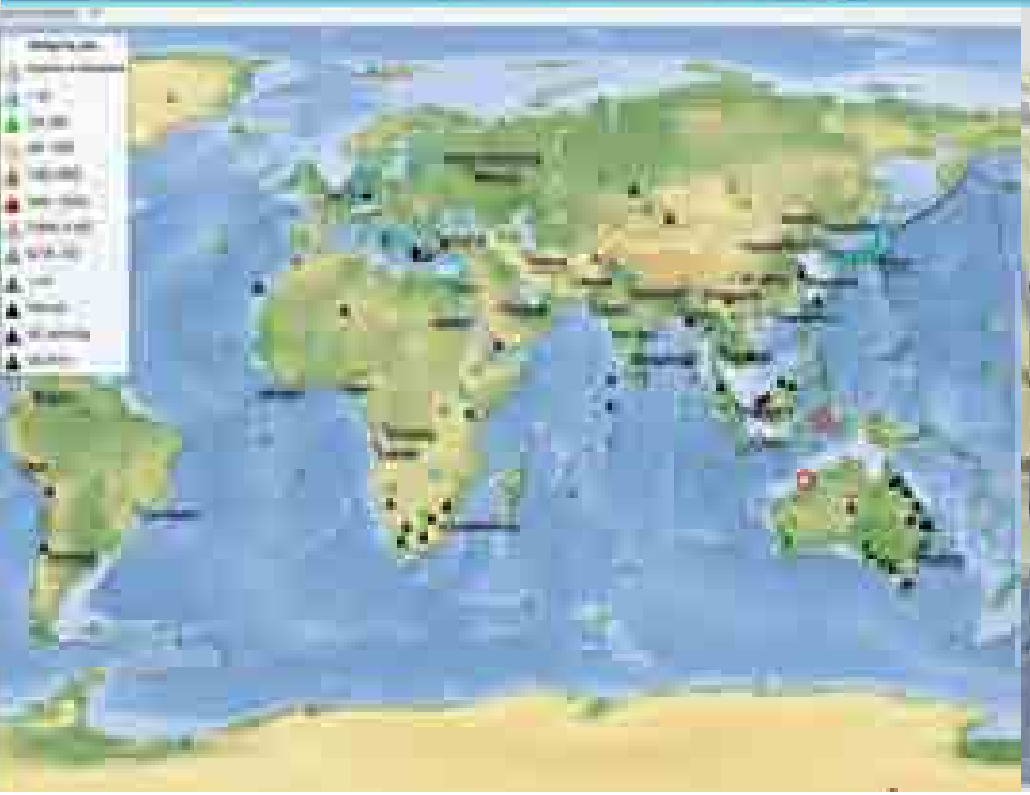
•Data Acquisition, Display, Processing, Archival

Numerical Modeling and Decision Support

Generation of Advisories and Dissemination

•Mission Critical - Infrastructure to be highly available

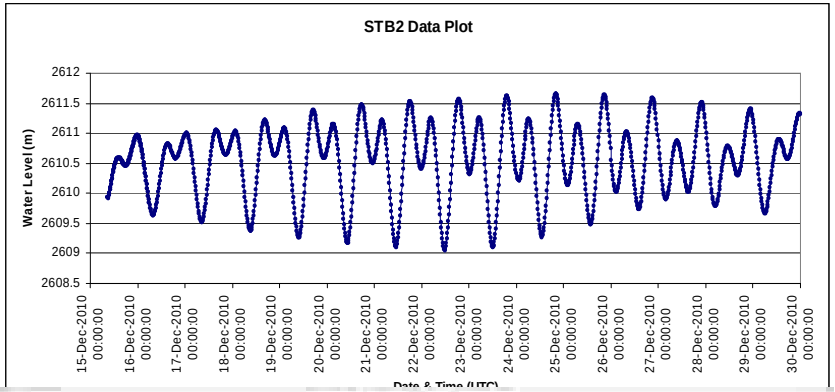
Seismic Network

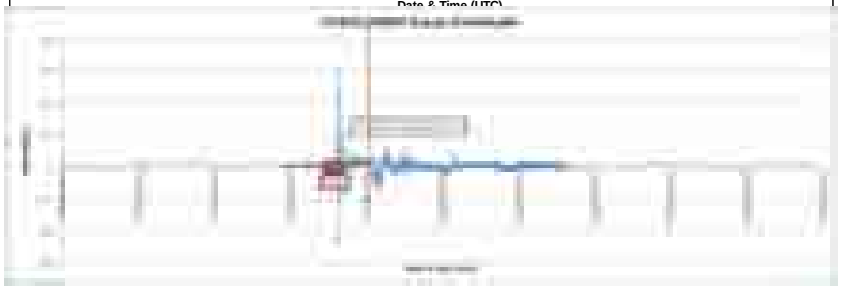


- Real-time Seismic Monitoring Network of 27 broadband seismic stations
- Receives data from around 130 seismic stations (operated by various national agencies) ISGN which is maintained by NCS & INCOIS
- Seismic data from International stations (GEOFON / IRIS) around 350 Stations
- Data Acquisition, Processing, Auto location and Archival using Response SeisComP 3.0 and Bulletin Hydra
- Auto-location within 5 to 10 min of occurrence of an earthquake
- EQ parameters matching well with those put out by USGS / GEOFON

Indian Tsunami Buoy Network

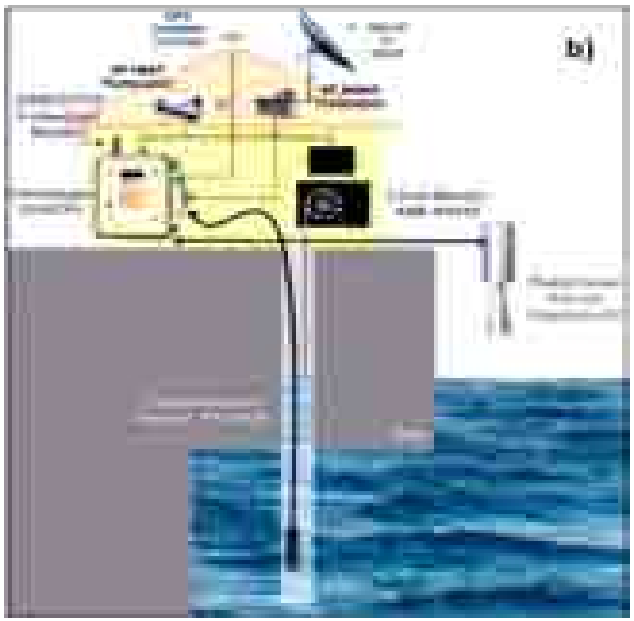
- **Indian Tsunami Buoys Network**
  - Real-time Network of 7 Tsunami Buoy systems
  - Six systems are operational, (four SAIC Tsunami Buoys and two Indigenous Tsunami Buoys of NIOT)
  - Data is being received in real-time via acoustic & Satellite links
  - Seven tsunami buoys (STB01, STB02, STB03, STB04, STB05, ITB09, and ITB12) data sharing to NDBC/NOAA

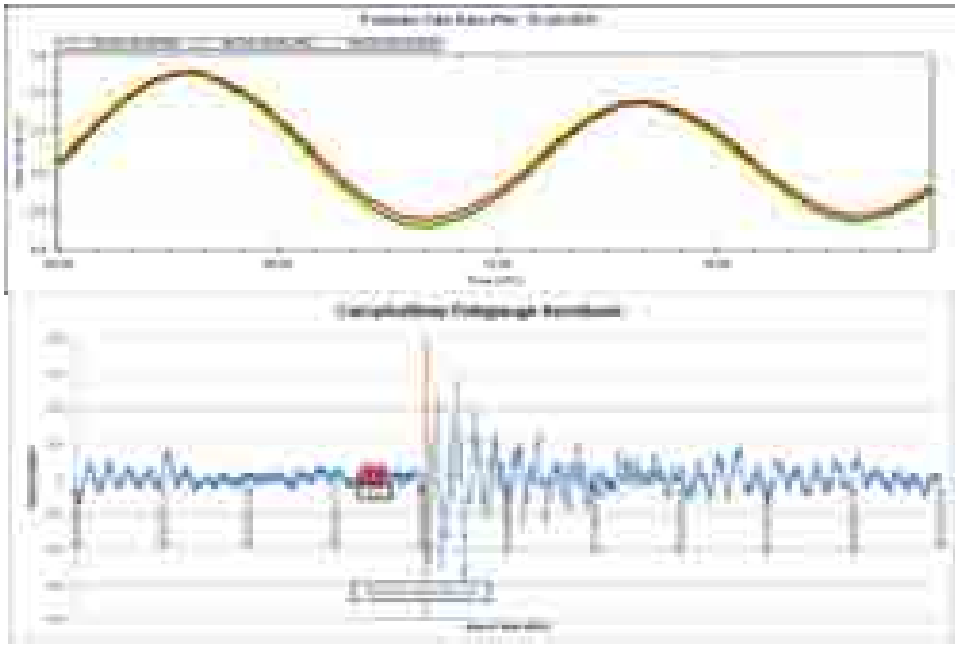




Indian Tide gauge Network

- **Indian Tide gauge Network**
  - INCOIS installed 35 tide gauge station along Indian coast line and Islands
  - Receiving 14 tide gauges data from NIOT
  - Communication through INSAT/GPRS/FTP
  - Eight Tide gauges data (Chennai, Kochi, Nancowry, Portblair, Visakhapatnam, Minicoy, Marmagao and Veraval) to IOC Sea level stations monitoring facility

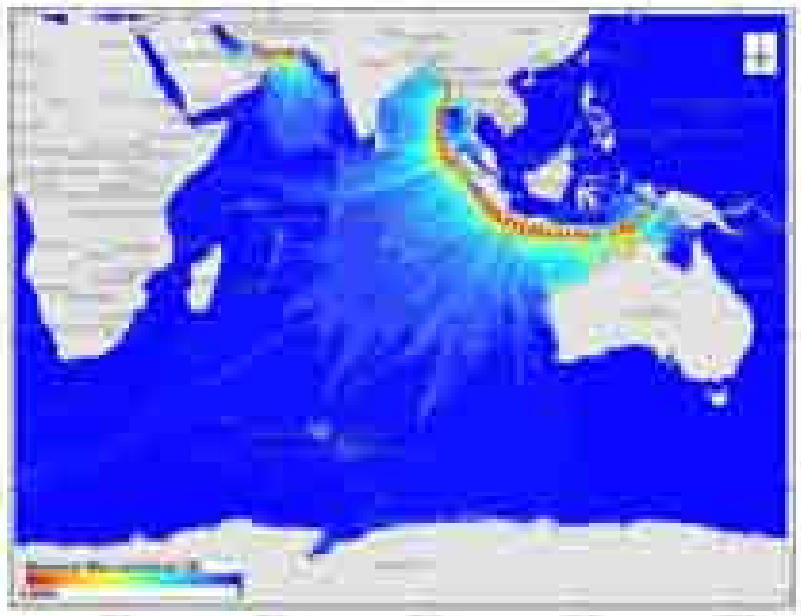


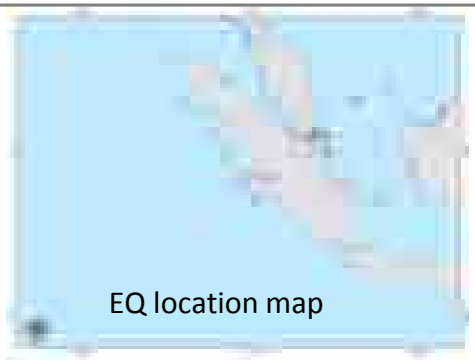


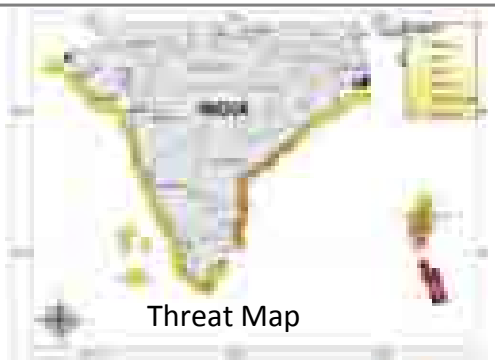
Operational Tsunami Forecast

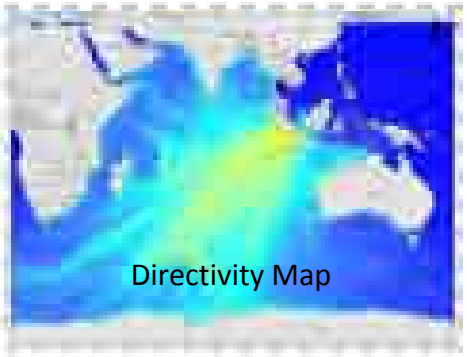
Tsunami Modelling (OOPS DB)

- Large Database of open ocean propagation scenarios (oops db) covering both Makran and Sunda Tsunamigenic Zones
- Model Domain with 3.2 million grids
- ~1400 unit sources each of 100 X 50 km area representing rupture caused by EQ of M 7.5 with slip as 1m
- Depending on EQ's location and magnitude basic unit source OOPS DB scenrios are either scaled up or down
- Expected Wave Arrival & Amplitude forecasts at 4380 Costal Forecast Points (CFPs) in the Indian Ocean Coast
- CFPs are then rendered to create threat profile for Coastal Forecast Zones (CFZs)





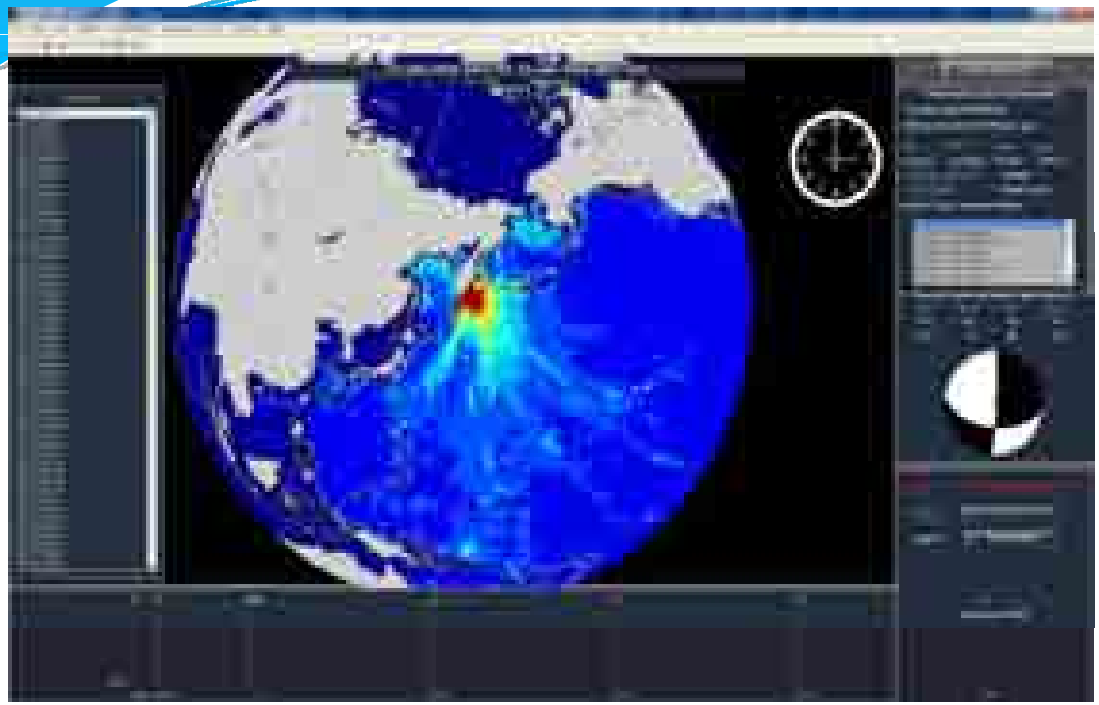




Quantitative Forecast

- **T1** (Time of arrival of the minimum detectable positive amplitude wave)
- **T2** (Time of first exceedance of the Threat Threshold)
- **T3** (Time of arrival of max_beach)
- **T4** (Time when the last exceedance of the Threat Threshold is forecast)
- **max_beach** / EWA-Estimated Wave Amplitude(Maximum Positive wave amplitude at the shore line)
- **max_deep** (Maximum positive wave amplitude in deep water in each coastal zone)
- **Depth** (Depth of the water where the max_deep occurs)
- **Threat Status** (Warining/Alert/Watch) based on Expected Arrival times and Estimated Amplitudes
- Timely Tsunami forecast by following **Standard Operating Procedure** (SOP)

Decision support system



➢New Decision Support System 2016:

Dash Board

✓Captures real-time earthquake information from multiple sources and display earthquake location with focal mechanism

Situation Analysis

✓Access to **Open Ocean Propagation Scenario Database** (OOPS DB) in optimized way

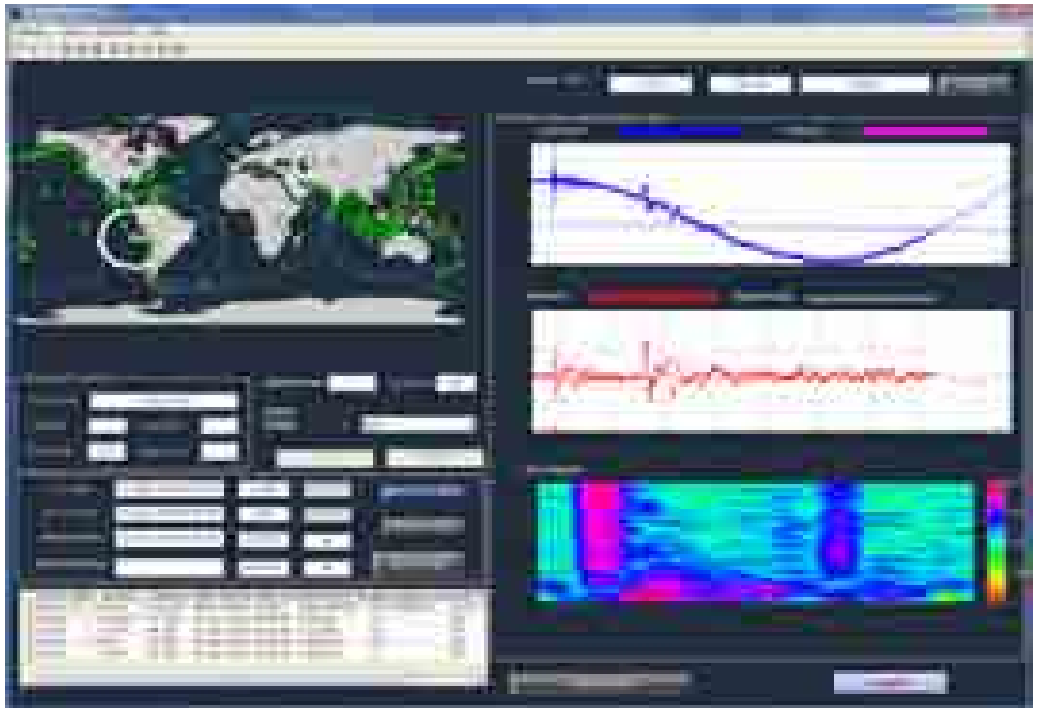
✓Near **real time Tsunami Model launch** with available Focal Mechanism for **Open Ocean Propagation** results

Observation Analysis

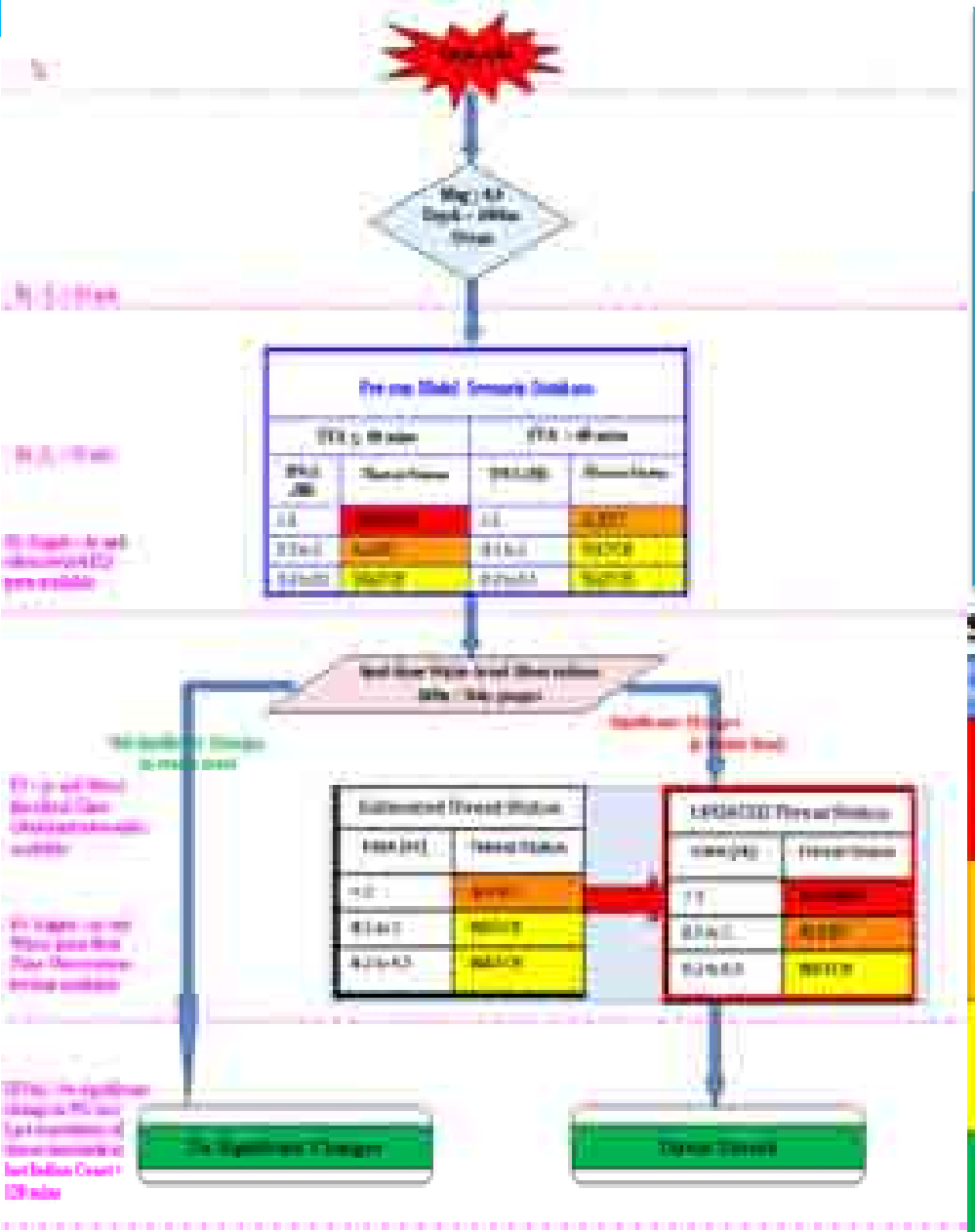
✓**Real-time access** to all National and **International Sea level stations** data

✓Real-time calculations of residual data

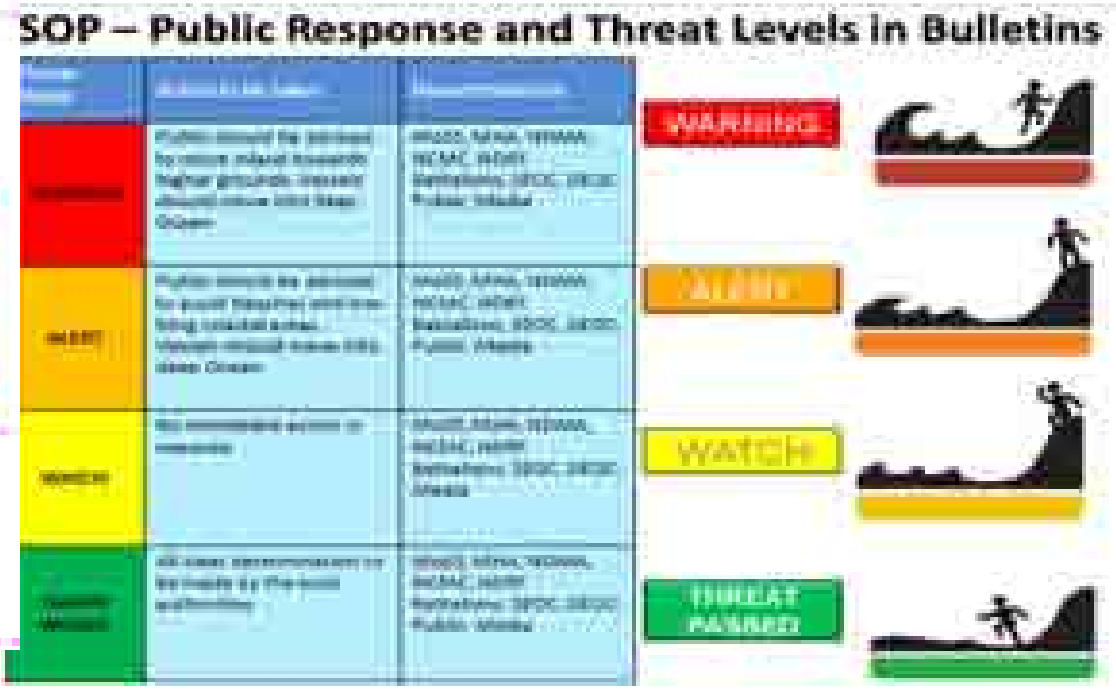
✓**Sea level inversion** to get slip distribution of tsunamigenic source



Standard Operating Procedure (SOP)

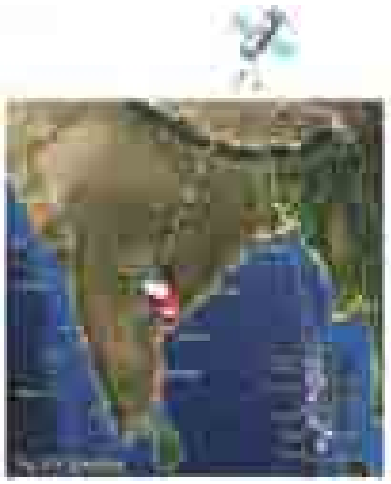


- The ITEWC services for an event commence whenever an earthquake is recorded with M ≥ 6.5 within the Indian Ocean and M ≥ 8.0 outside of the Indian Ocean
- Uniquely designed SOP for generation of timely and accurate tsunami bulletins to handle both near-source and far-source coastal regions
- Based on proximity of a coastal zone to the tsunamigenic earthquake source regions and Expected Wave Heights from Models
- 4 Threat Levels corresponding to different public responses and mapped to NDMA guidelines



Product Formats & Dissemination

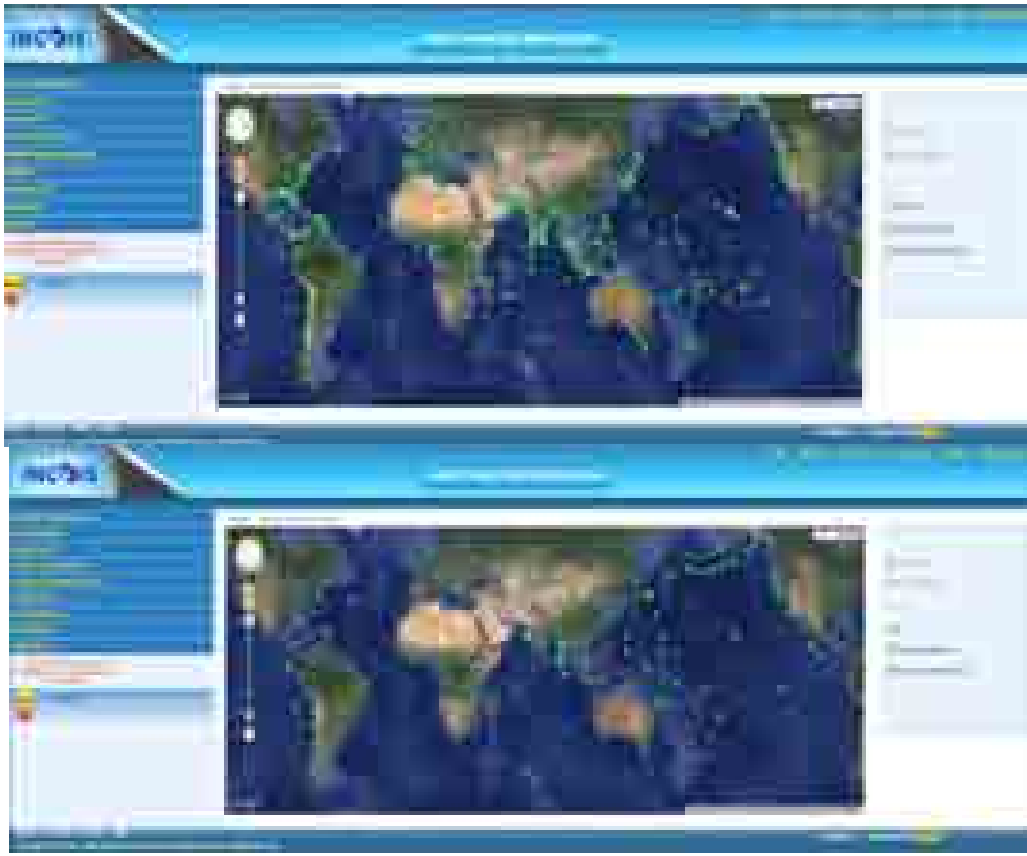
- **Notification Messages** are issued in **text** format
- **Bulletins** are generated in both text and **HTML formats** on the websites
- **Graphics** are generated in jpg or png format on the websites
- **Spatial** data is also available in dbf format on the websites



Tsunami Website

The following is the link for Indian Tsunami Early Warning Centre, INCOIS website:
http://www.incois.gov.in/Incois/tsunami/eqevents.jsp

Latest Earthquake & Sea level data also available at:
http://tsunami.incois.gov.in/



Tsunami Preparedness & Response

➢ Communications Tests (Comms Test)

- To validate the dissemination and reception processes of advisories in all possible communication modes and to determine transmission times of messages

➢ SOP Workshops

- For DMOs to build their own SOPs detailing actions to be taken upon receipt of bulletins from the warning centre

➢ Tabletop Exercises

- To stimulate the development, training, testing and evaluation of Emergency Response Plans, SOPs and assess procedures followed (Conducted in a conference room environment)

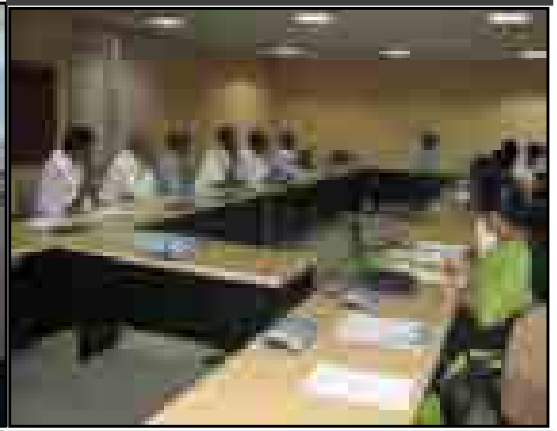
➢ Mock Drills

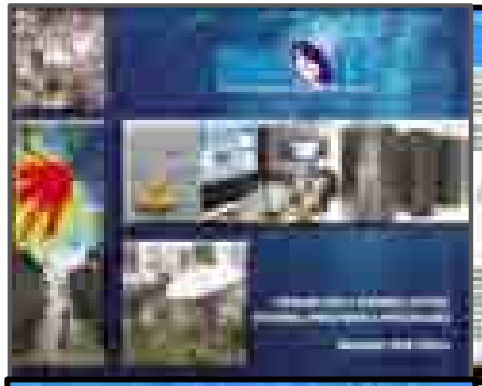
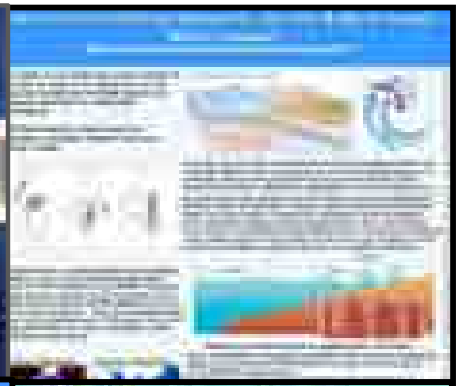
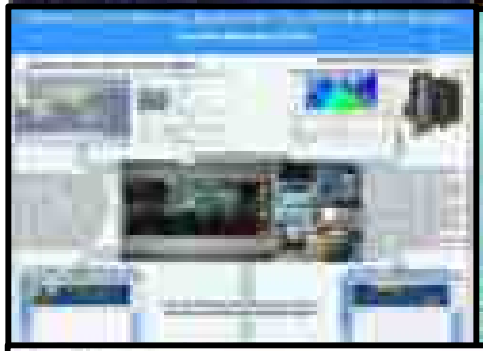
- Full scale mock Tsunami Drill to evaluate and improve the effectiveness of SOPs of TWC and DMOs, in responding to a potentially destructive tsunami

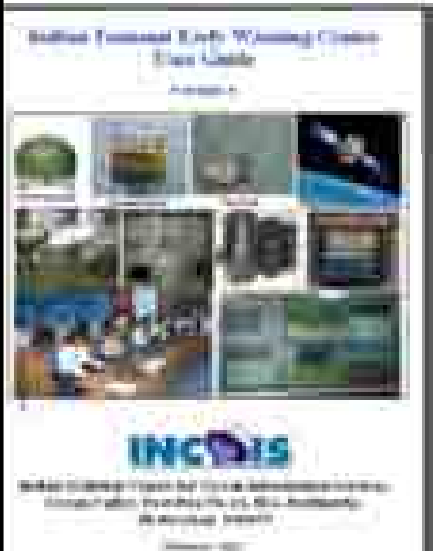
Capacity Building

Workshops, Trainings, Education Material etc



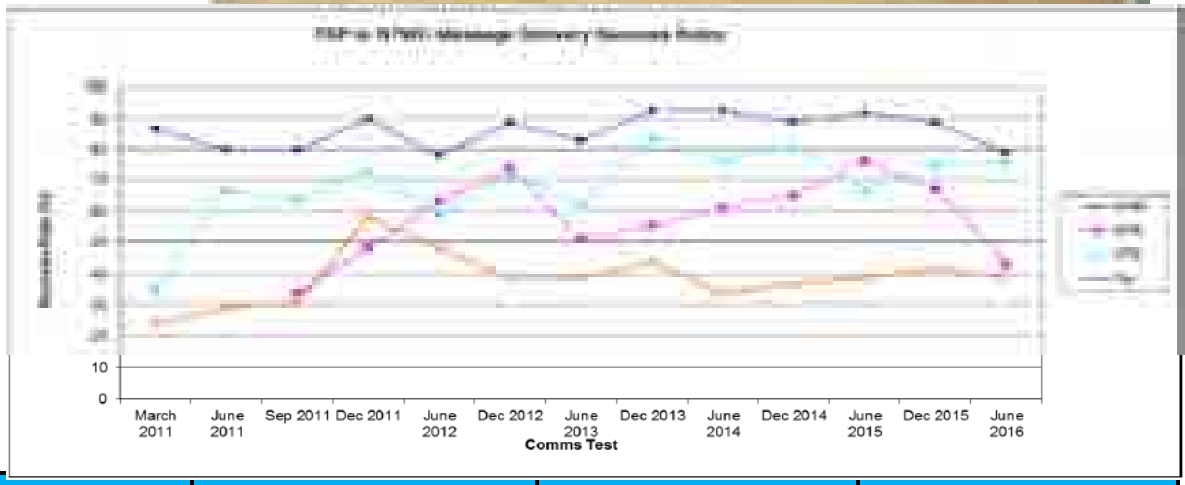





Communication Tests

1. March 16, 2011 (NTWCs)
2. June 15, 2011 (NTWCs & National DMOs)
3. September 14, 2011 (NTWCs & National DMOs)
4. December 14, 2011 (NTWCs)
5. June 13, 2012 (NTWCs)
6. December 12, 2012 (NTWCs)
7. June 13, 2013 (NTWCs & National DMOs)
8. December 11, 2013 (NTWCs)
9. June 11, 2014 (NTWCs)
10. December 10, 2014 (NTWCs)
11. June 10, 2015 (NTWCs)
12. Dec 9, 2015 (NTWCs)
13. Jun 8, 2016 (NTWCs)
14. Dec 14, 2016 (NTWCs)

- Modes of Communication
  - International: Email, Fax, GTS, SMS, Web
  - National: Email, Fax, SMS, Web
- Performance till now:
  - Compared 13 COMMs test results
  - Email the most significant mode of communication



	16 Mar 2011		15 Jun 2011		14 Sep 2011		14 Dec 2011		13 Jun 2012		12 Dec 2012	
Mode	No. of NTWCs Received	Time Delay (Mins)	No. of NTWCs Received	Time Delay (Mins)	No. of NTWCs Received	Time Delay (Mins)	No. of NTWCs Received	Time Delay (Mins)	No. of NTWCs Received	Time Delay (Mins)	No. of NTWCs Received	Time Delay (Mins)
Email	19/23	0 – 48	20/22	0 – 48	22/23	0 – 15	17/19	0 – 9	18/21	0 – 2	15/17	0 – 4
Fax	7/23	0 – 61	10/22	0 – 91	12/23	0 – 93	13/19	0 – 35	12/21	0 – 35	6/17	0 – 32
GTS	12/23	0 – 5	17/22	0 – 17	17/23	0 – 26	16/19	0 – 25	15/21	0 – 7	12/17	0 – 14
SMS	--	--	--	--	13/23	0 – 13	15/19	0 – 23	15/21	0 – 1	14/17	0 – 3

	12 Jun 2013		11 Dec 2013		11 Jun 2014		10 Dec 2014		10 Jun 2015		9 Dec 2015		8 Jun 2016	
Mode	No. of NTWCs Received	Time Delay (Mins)	No. of NTWCs Received	Time Delay (Mins)	No. of NTWCs Received	Time Delay (Mins)	No. of NTWCs Received	Time Delay (Mins)	No. of NTWCs Received	Time Delay (Mins)	No. of NTWCs Received	Time Delay (Mins)	No. of NTWCs Received	Time Delay (Mins)
Email	19/20	0-5	21/21	0 - 16	21/23	0 - 28	23/24	0 - 2	20/21	0 - 2	18/20	0 - 2	20/23	0-2
Fax	15/20	0- 184	18/21	0- 32	13/23	0 - 20	17/24	0 - 15	12/21	0 - 15	16/20	0 - 15	15/23	0-15
GTS	14/20	0 – 40	17/21	0 - 4	19/23	0 - 10	20/21	0 - 16	17/21	0 - 10	18/20	0 - 3	18/23	0 - 3
SMS	14/20	0 - 9	15/21	0 - 2	14/23	0- 37	20/23	0- 2	19/21	0- 2	18/20	0- 2	18/23	0 - 3

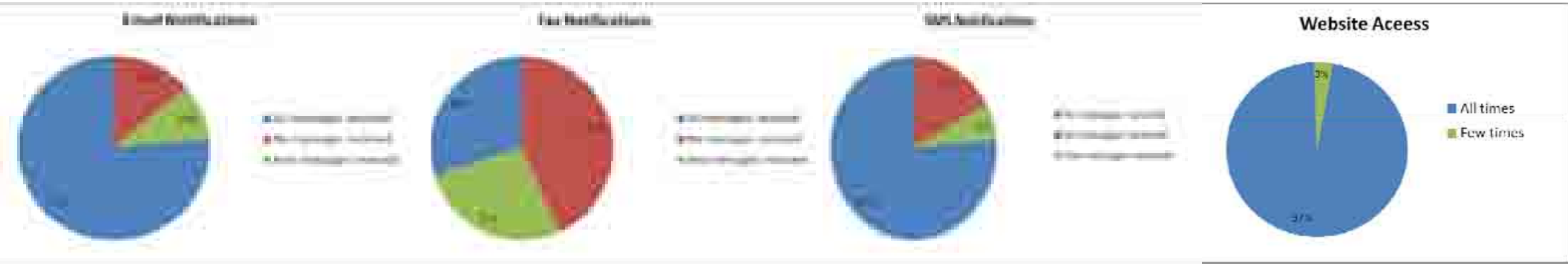
Tsunami Mock drills

➢ Objectives of Mock Drill:

- Validate the Warning Centre dissemination process for issuing Tsunami Advisory Bulletins to national disaster management authorities and other participating agencies.
- Evaluate the processes and procedures of agencies receiving and confirming Tsunami Bulletins.
- Hone the organizational decision making process about public warnings and evacuations.
- Identify the proper communication methods that would be used to notify and instruct the public.
- Record and assess the elapsed time until the public would be notified and instructed.

➢ Previous Drills

- IOWave09 on October 14, 2009
- IOWave11 on October 12, 2011
- A&N Islands on November 22, 2013
- IOWave14 on September 9 & 10, 2014
- East Coast of India on September 26, 2015
- Kerala Coast on March 10-11, 2016
- IOWave16 on September 7 & 8, 2016



Tsunami Mock drill-IOWave16

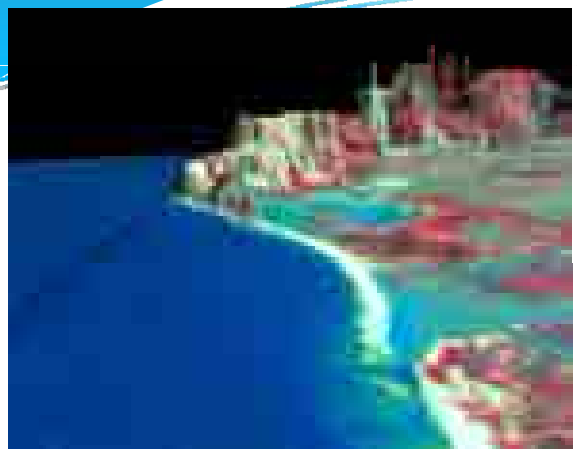
IOWave16 Tsunami mock drill on Sept 7-8, 2016

- The IOWave16 Exercise was very successful which improved awareness and preparedness among the coastal people of India
- Around 350 villages from 33 districts of 8 coastal States/UTs were involved and evacuated during the mock drill
- Response time was varying from 15-55 minutes to notify the public
- More than 40,000 people were evacuated to shelters/safe places during mock drill
- Different modes of communication Telephone, SMS, Whatsapp, Twitter, Public radio, TV, website, Siren, Public Alert System, Police, Door-to-door, Mega phone, VHF, etc. were used
- Most recipients agreed the exercise was very satisfactory and suggested to conducts regular Mock exercise to create more awareness and preparedness

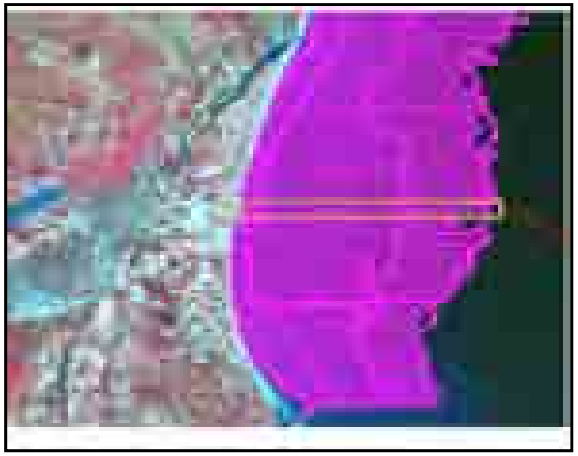
Elapsed time until the public is notified

Location	Making a decision on public warning (From time of receipt of warning)	Formulation/ compilation of public Notification (From time of decision)	Activation of public notification systems (From time of notification formulated)	Total Time (in Minutes)	Apprx No. of people evacuated
West Bengal	05	05	10	20	3,256
Odisha	15	15	15	45	30,000
Andhra Pradesh	10	20	25	55	3,733
Tamil Nadu	05	05	05	15	2,850
Andaman & Nicobar	Inputs not yet received				
Kerala	05	10	20	35	3,453
Karnataka	15	10	10	35	512
Gujarat	10	8	5	23	1,308

Coastal Inundation Mapping

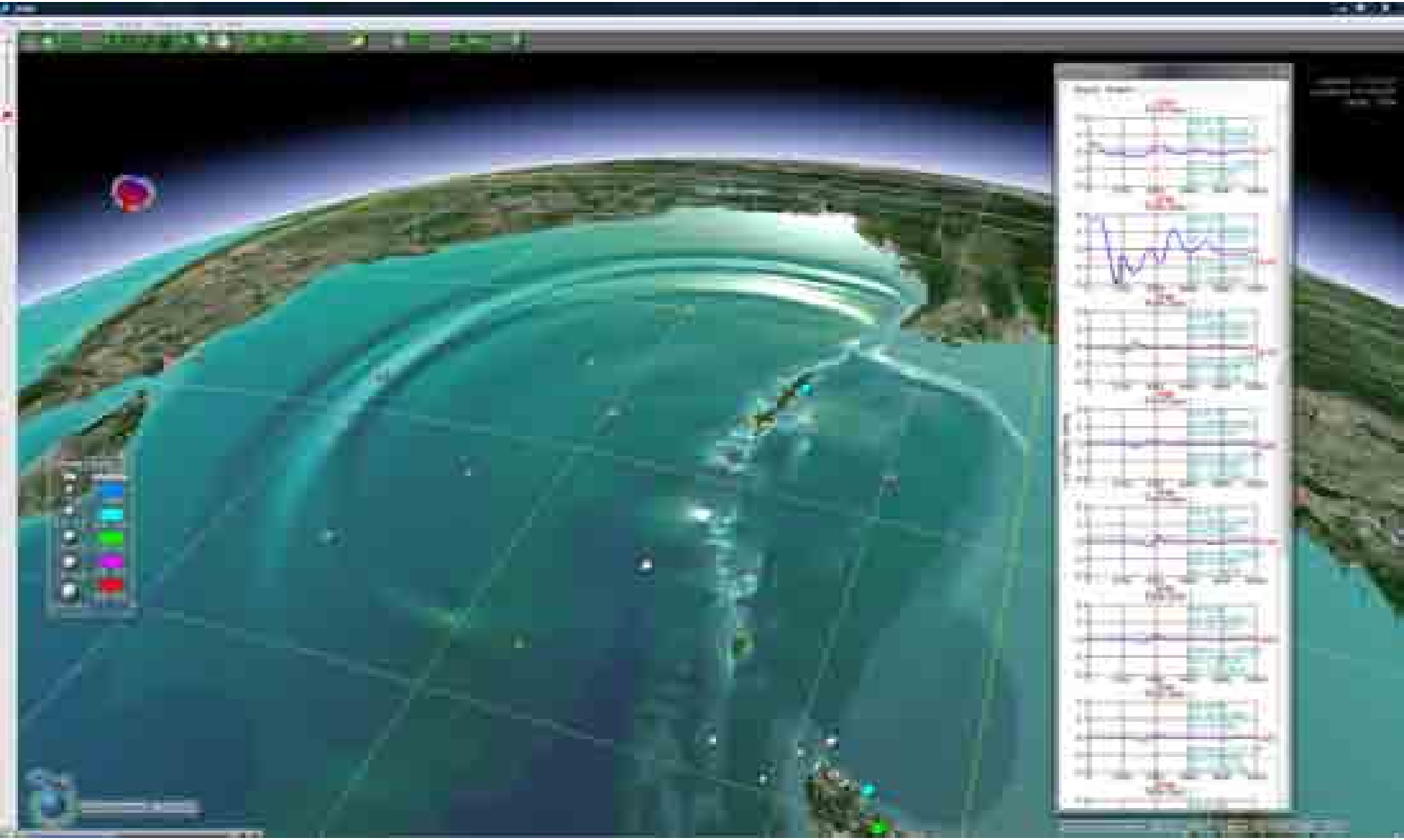


1m contours overlaid on ortho image

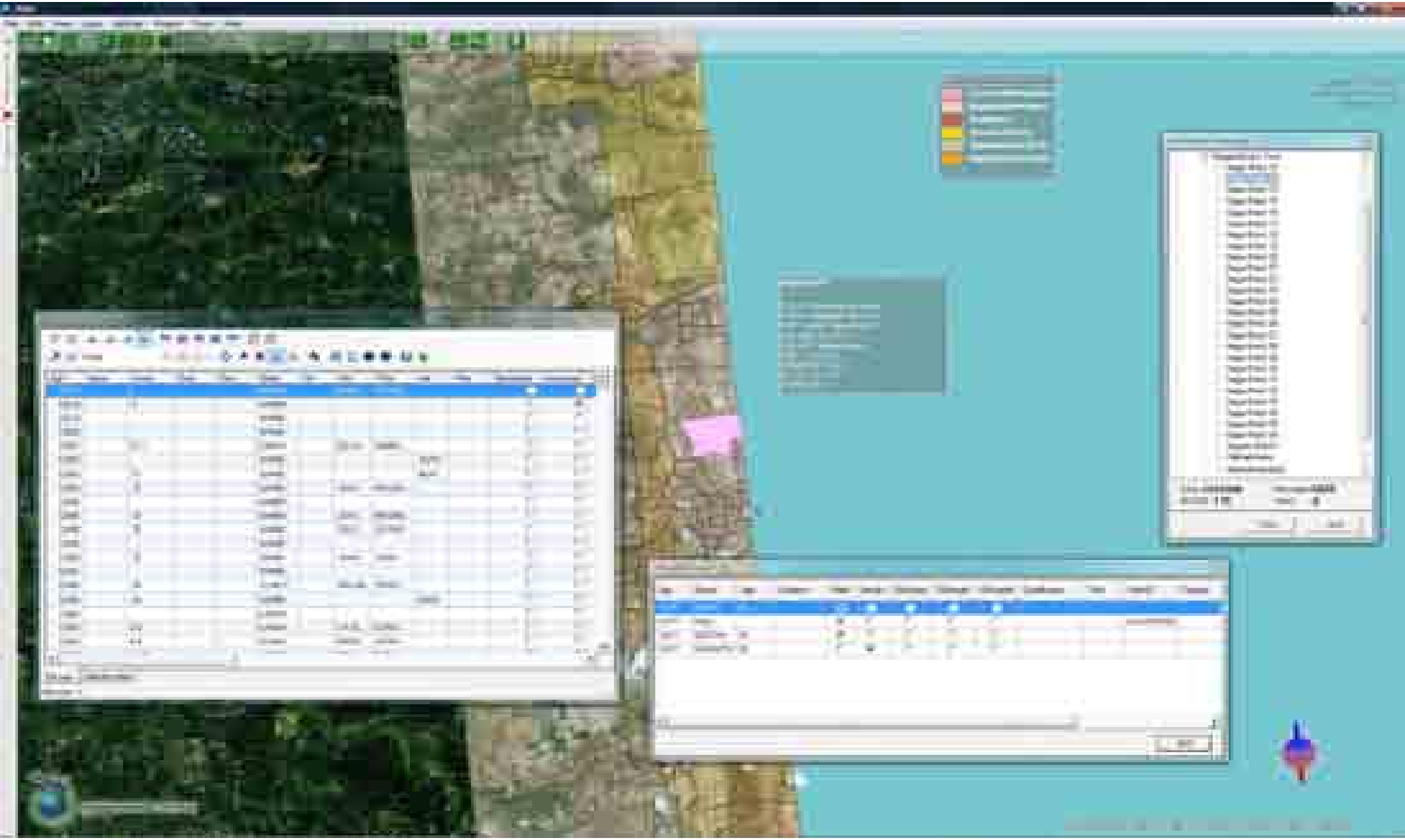


Bathymetric Survey for Cuddalore

- Coastal Inundation scenarios simulated for 5 historical Earthquakes using TUNAMI N2 model and the predicted inundation areas have been overlaid on cadastral level maps of 1:5000 scale.
- Coastal Bathymetry: Maps of Special Order are required (Accuracy 0.5 M)
- Coastal Topography: Contour Intervals of 0.5 M at 1:25, 000 Scale are required
- Topography Data being generated using Cartosat and ALTM Surveys
- Bathymetric Survey conducted for a few vulnerable areas. Detailed survey being planned for other areas.



Numerical modeling of the tsunami propagation using ITRIS shell



Administrative boundaries with the building, people and other information

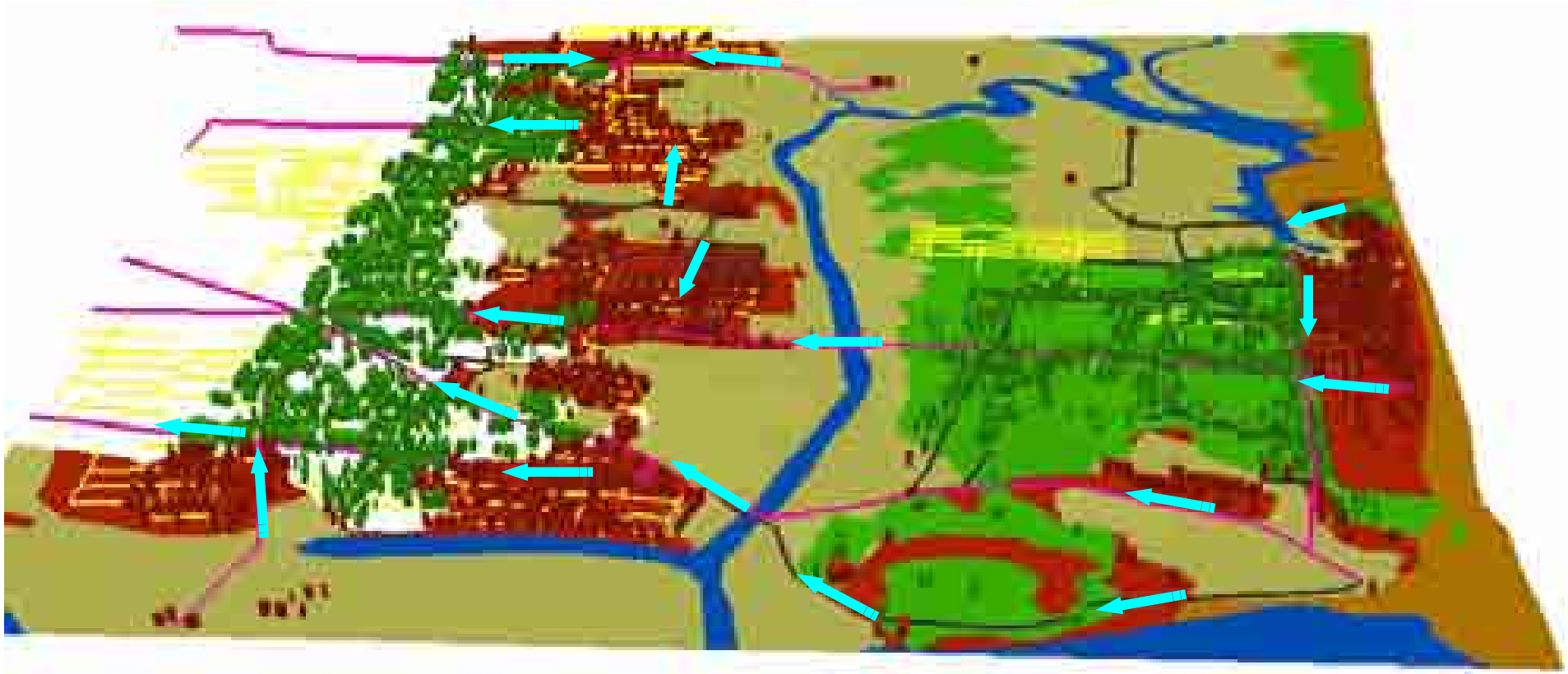
ITRIS allows to select any area of the Earth surface and zoom in on this area up to the highest resolution 60 cm (if a certain satellite imagery of the highest resolution is available)

Manipulation with realistic 3D models and textures of real buildings. Provides the possibility for including of real object images (peoples, items, signs) in a 3D model. The building brief (address, telephone, owner) appears in the pop-up information box. (This example is Nagapattinam India).

Evacuation Plans

- Geographical size of the management area
- Regional topography
- Regional hazards and vulnerabilities
- Size and density of the population
- Resources available

Evacuation Route



Risk

- High
- Moderate
- Low
- No Risk

Buildings

- Hazard
- Safe

Roads

- Major
- Minor
- Streets
- Evacuation Routes

Dos and Don'ts

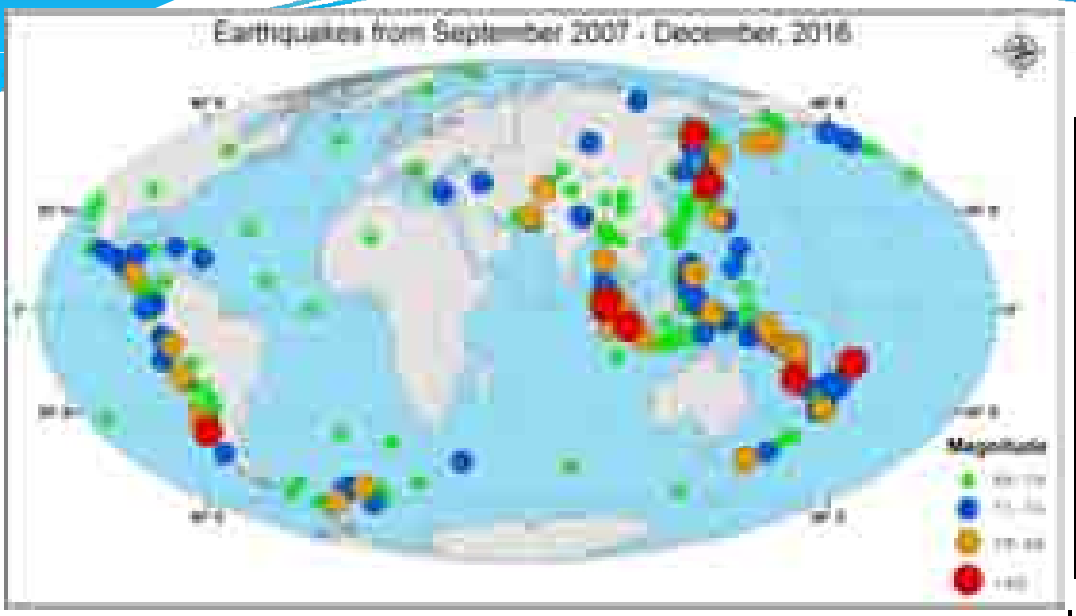
Dos

- Know whether you are in a tsunami hazard zone or not.
- Know where the nearest tsunami escape route is.
- If your very near to tsunamigenic zone, Read natural signs such as strong ground shaking, receding of water in Sea, deep cracking sound, strange animal behavior, etc.
- Have already put together portable emergency survival kits for you and your family.
- Listen to the Tsunami sirens and other warnings like announcement on radio, loud speakers, etc.
- Be aware of all the Relief Shelters and Godown.
- Identify the higher grounds, high rise concrete buildings and also inland areas far off from the shore.
- In case of non availability of building, climb a tree or clutch a floating object.
- If on a boat in the open sea, stay put as one is safe out there.
- Wait for an official announcement that the danger has passed before returning home or to the beach.
- Help others…

Donts

- Don't rush to the beach to see the big wave.
- Don't Wait for an official warning if you feel an earthquake that lasts a minute or more, are on the beach and the tide suddenly goes out, or you see a wall of water rushing toward you.
- Stop to pack your most cherished possessions to take with you.
- Don't overstuff survival kits with heavy articles.
- Don't use well water as it can be contaminated.
- Do not move to the Coastal areas until the tsunami threat has passed and the "all clear" is announced by the Administration as there could be more Tsunami waves.

Performance of ITEWC

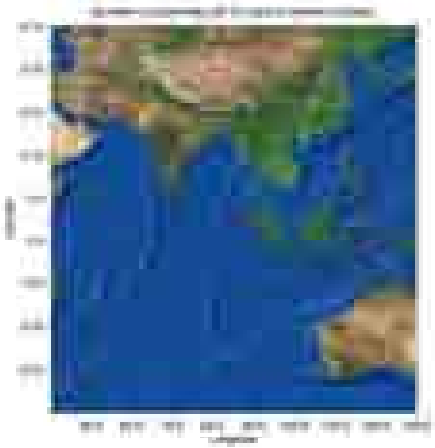


ITEWC monitored 525 earthquakes (M>6.5) during Sep 2007 to Dec 2016

Region	No of Earthquake M≥6.5
Indian Ocean **(IO)**	88
Other than Indian Ocean (GO)	437

Parameter	Target (local/distant)	Achievement GO	Achievement IO
Elapse time from earthquake origin time to initial earthquake information issuance	10/15 min	9.3 min	8.5 min
Probability of detection of Indian Ocean earthquakes with *Mw* ≥ 6.5	100%	100%	100%
Accuracy of hypocenter location (with respect to USGS final estimates)	Within 30 km	14.2 Km	14.5 Km
Accuracy of hypocentre depth (with respect to USGS final estimates)	Within 25 km	14.7 Km	19.0 Km
Accuracy of earthquake *Mw* magnitude (with respect to USGS final estimates)	0.3	0.25	0.20

Off West Coast Of Northern Sumatra, 11 Apr 2012



Off W Coast of Northern Sumatra Earthquake of Magnitude 8.5

On 12-Apr-2012 08:38 UTC (14:08 IST)

This event generated very minor tsunami in Indian Coasts.

Issued Bulletins:

Bulletin No 1: Earthquake Information M8.7

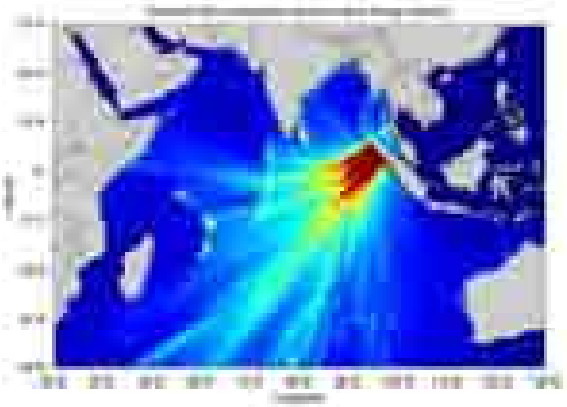
Bulletin No 2: Tsunami Warning issued for Indira Point, Car Nicobar, Komatra & Katchal Islands

Bulletin No 3: Revised M8.5 and Warning for Indira Point, Komatra & Katchal Islands And remaining A&N Islands under Alert; STB01 water level observation is 0.10 m

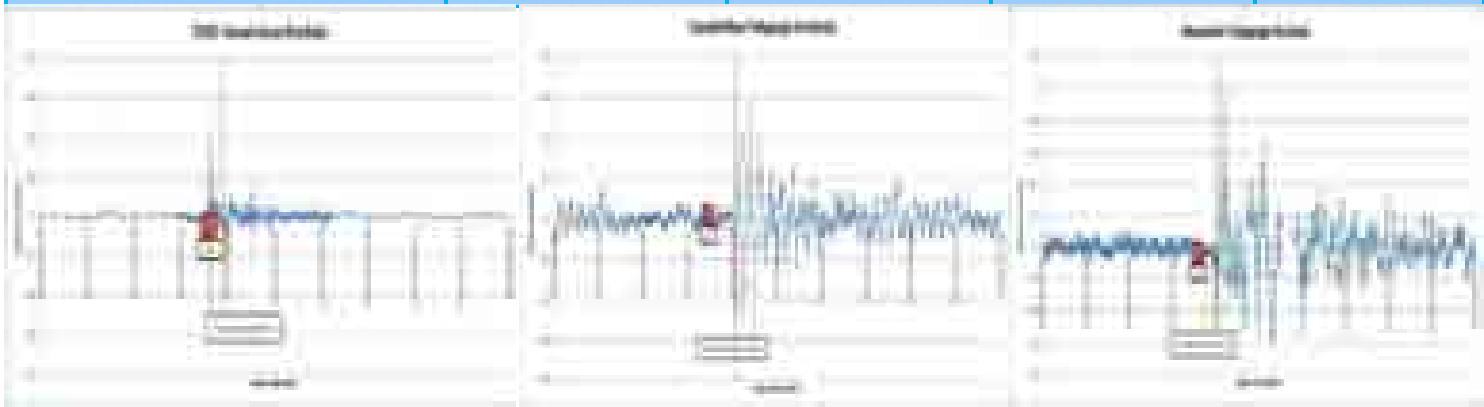
Bulletin No 4: Continued Warning & Alert; water levels observed 0.30 m at Campbell bay & Sabang

Bulletin No 5: Continued Warning & Alert; water levels observed 0.60 m at Meulboh & 0.10 m at Nancowry

Bulletin No 6: Based on minor tsunami observation; Tsunami Warning/Alert/Watch Cancelled



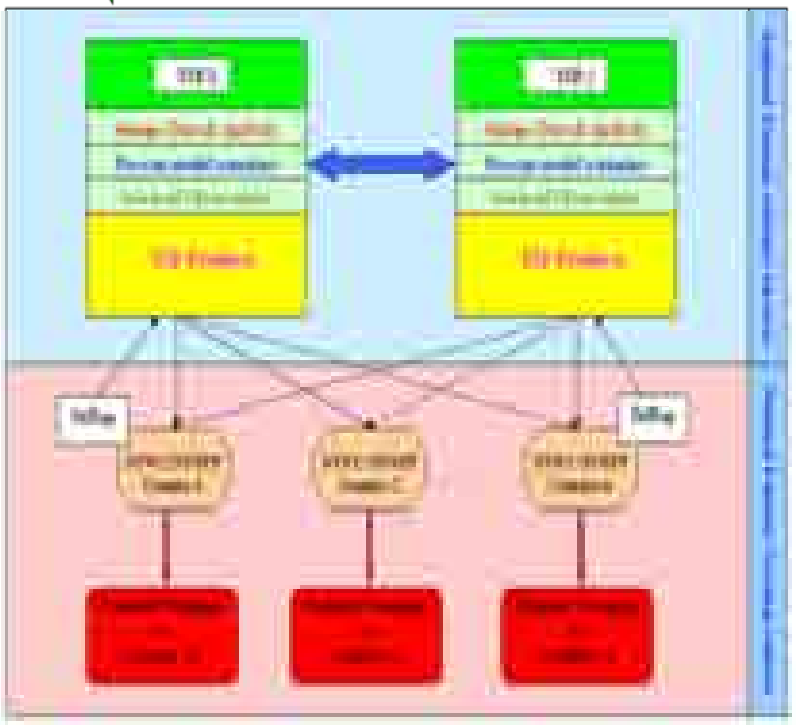
INCOIS	InaTEWS	JATWC	PTWC	JMA
Tsunami Evaluation: Indira Point, Car-nicobar and Komatra & Katchal islands of Andaman & Nicobar Islands are in "Warning", Tamilnadu, Andhra Pradesh and rest of the Andaman Islands as "Alert" & few areas of the mainland under "Watch". After confirmation of minor water level observations; Tsunami Warning/ Alert/ Watch Cancelled	Tsunami Evaluation: Andaman & Nicobar Islands, Tamilnadu, Andhra Pradesh, Orissa, Kerala, Karnataka and Maharastra are under Threat (EWA ≥ 0.5 m). Later cancelled	Tsunami Evaluation: Andaman & Nicobar Islands and Tamilnadu are under Threat (EWA ≥ 0.5 m). Later cancelled	Tsunami Evaluation: Entire Indian coast under tsunami Watch (Under Threat). Later cancelled	Tsunami Evaluation: Entire Indian coast under tsunami Watch (Under Threat).



India as Tsunami Service Provider (TSP)

ITEWC is playing major role in UNESCO/IOC Tsunami Warning Initiatives

- Indian Scientists played a major role in designing the IOTWMS system
- India had been Founding Chair of ICG/IOTWMS
- India had been vice-chair for IOWave & Capacity Assessment of Tsunami Preparedness Task Teams
- India is Chair for Task Team on Tsunami Watch Operations which is working towards Global Harmonization
- IOTWS is a network of National Systems consisting of **TSPs** and **NTWCs/NTFPs**
- TSPs distribute products to NTWCs and other TSPs within a region and as a backup of each region there should be **more than one RTSP** for each region
- **NTWCs/NTFPs are solely responsible for providing warnings to their citizens based on their analysis of the situation**
- India first to initiate exchange of Earthquake information (SL-1) in 2008
- In 2011 formally India started exchanging Model based advisories (SL-2)
- On October 12, 2011 UNESCO handed over the responsibility of Indian Ocean tsunami advisories to the Tsunami Service Providers India, Australia, Indonesia
- As a Tsunami Service Provider (TSP) India is providing bulletins to all Indian Ocean rim countries, together with TSPs Australia & Indonesia



S. No	Performance Indicator	Target	Achievement
PI 1	Elapsed time of issuing first earthquake bulletin after earthquake	10 min	9.79min
PI 2	Probability of Detection of IO EQ with Mw >= 6.5	100 %	100%
PI 3	Accuracy of Earthquake Parameters, in comparison with final estimates from USGS		
a	Magnitude	0.3	0.1
b	Depth	25 km	7.46 km
c	Location	30 km	16.5 km
PI 4	Elapsed time of issuing first tsunami threat assessment bulletin after earthquake	20 min	18 min
PI 5	Probability of detection tsunamis above threat threshold	100%	NA / 100%
PI 6	Accuracy of tsunami wave height predictions	Factor of 2	NA

Tsunami Services for South Asia

- INCOIS is providing services to Indian Ocean rim (28) countries along with Australia and Indonesia
- Out of 8 SAARC countries, 5 Countries are Bangladesh, India, Maldives, Pakistan and Sri Lanka having the coastal line and INCOIS is providing timely tsunami advisories for these Countries
- Focal contacts of each Country for Tsunami Warnings:
  - **Bangladesh**: Bangladesh Meteorological Department, Agargoan, Dhaka-1207
  - **India**: Indian Ocean Centre for Ocean Information Services (INCOIS), Pragathi Nagar, Nizampet (SO), Hyderabad – 500090
  - **Maldives**: Maldives Meteorological Service, Hulhule, 22000, Maldives
  - **Pakistan**: National Seismic Monitoring Centre, Pakistan Meteorological Department, University Road, Gulistan-e-Johar, Karachi, Pakistan
  - **Sri Lanka**: Department of Meteorology, 383 Bauddhaloka Mawatha, Colombo 07, Sri Lanka

THANK YOU